DTIC FILE COPY

(2)

Naval Research Laboratory

Washington, DC 20375-5000

NRL Memorandum Report 6074
(Revised January 20, 1988)

The Ex-Shadwell— Full Scale Fire Research and Test Ship

HOMER W. CARHART AND FREDERICK W. WILLIAMS

Navy Technology Center for Safety and Survivability
Chemistry Division

October 6, 1987

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No 0704-0188

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S) NRL Memorandum Report 6074 (Revised 1/20/88)	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION Naval Research Laboratory 6b OFFICE SYMBOL (If applicable) Code 6180	7a NAME OF MONITORING ORGANIZATION
6c ADDRESS (City, State, and ZIP Code) Washington, DC 20375-5000	7b ADDRESS (City, State, and ZIP Code)
8a NAME OF FUNDING/SPONSORING ORGANIZATION Naval Sea System Command 8b OFFICE SYMBOL (If applicable) SEA05R23	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c ADDRESS (City, State, and ZIP Code) Washington, DC 20362-5101	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO: 64516N PROJECT NO: S1828 TASK NO: WORK UNIT ACCESSION NO: DN480-684

11 TITLE (Include Security Classification)
The Ex-Shadwell—Full Scale Fire Research and Test Ship

12 PERSONAL AUTHOR(S)
Carhart, Homer W. and Williams, Frederick W.

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Interim	FROM ____ TO ____	1987 October 6	103

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Fire; Damage Control; Integrated testing; Shipboard testing

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

The EX-SHADWELL is a decomissioned Landing Ship Dock (LSD-15) which is being converted to a damage control test bed. Full scale testing of most facets of damage control can be accomplished on this ship. It will be located at the U.S. Coast Guard Fire and Safety Test Detachment, Mobile, Alabama.

This report describes the overall general capabilities for the EX-SHADWELL along with supporting documents for developing specific test plan for RDT&E aboard the vessel.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL Frederick W. Williams	22b TELEPHONE (Include Area Code) (202) 767-2476 — 22c OFFICE SYMBOL Code 6180

DD Form 1473, JUN 86 — Previous editions are obsolete — SECURITY CLASSIFICATION OF THIS PAGE

CONTENTS

THE EX-SHADWELL - FULL SCALE FIRE RESEARCH AND TEST SHIP

BACKGROUND

The purpose of this report is to inform the reader of the current capabilities and plans for use of the EX-SHADWELL (LSD-15) in specific damage control tests and evaluations. The report is meant to be a living document and will change according to Navy needs, availability of the ship and funding. We hope also to stimulate the thinking of the reader so that input from various interests, such as the Fleet, Systems Commands (SYSCOMS), Training Commands, Chief of Naval Operations (OPNAV), Laboratories, other government agencies and industry can be used as an update to the report on a periodic basis. Written as well as oral comments are solicited and encouraged.

A Joint Research Agreement has been developed among the U.S. Coast Guard (USCG), Naval Sea Systems Command (NAVSEA) and Office of Naval Research (ONR)[Appendix A] concerning cooperation in research at the U.S. Coast Guard's Fire and Safety Test Detachment, Little Sand Island, Mobile, Alabama and where the EX-SHADWELL is berthed. The coordinator and custodian for the EX-SHADWELL is the Navy Technology Center for Safety and Survivability at the Naval Research Laboratory (NRL) Code 6180. The NRL point of contact is Dr. Frederick W. Williams, NRL Code 6180, commercial telephone number (202) 767-2476, Autovon 297-2476. The Naval Sea Systems Command points of contact are Mr. David Kay, NAVSEA Code 56Y52, commercial telephone number (202) 692-5515, Autovon 222-5515, and Mr. Carl Pohler, NAVSEA Code 05R23, commercial telephone number (202) 692-2980, Autovon 222-2980.

INTRODUCTION

U.S.S. SHADWELL (LSD-15) is now decommissioned and referred to as "EX-SHADWELL". Her vital statistics are: overall length 457'9", beam 72'0", full load displacement 9078 tons (ship isometric drawings can be found in Appendix B). She has a proud history of service during WW-II and performed what was termed a "miraculous" recovery after sustaining extensive damage by the enemy. "Damage Control" was required and saved this ship in the past, and now EX-SHADWELL serves the Navy again by providing a platform from which the "art" and science of ship survivability may be enhanced significantly because of the many opportunities she offers for realism in RDT&E which was not possible prior to her acquisition.

Manuscript approved July 10, 1987.

"Damage control is defined as the measures necessary to preserve or reestablish watertight integrity, stability, maneuverability, and offensive power; to control list and trim; to effect repairs of material; to limit the spread of and provide adequate protection from fire; to limit the spread of, remove the contamination by, and provide adequate protection against the effects of chemical and biological agents or noxious gases and nuclear radiation; and to provide for care of wounded personnel (Naval Warfare Procedure (NWP) 62-1)". Damage control includes the functional combination of all personnel, equipment, material, devices and techniques designed to prevent, minimize, or restore (recover from) damage which occurs in wartime or peacetime. This includes passive defense for conventional, nuclear, biological, and chemical warfare, and all active defense measures short of those designed to prevent successful delivery of enemy attack by military means or sabotage.

NAVSEA and the Navy Laboratories have long been in the business of providing hardware and software for the purpose of damage control. However, nothing stands in isolation, as indicated by the "functional combination" above. We have added the "personnel" in the make-up of damage control, for after all, man is an absolute prerequisite in reactive damage control. "Man", his understanding, his capabilities and his limitations are what we depend on for expression of problems and solutions. Fleet "feedback" on problems is often given to OPNAV, NAVSEA, the Navy Laboratories and others. The Fleet fulfills one of its functions, when it expresses these problems. The responsibility of the supporting community is to understand the problems, break them into manageable action items and develop corrective measures. Included in these corrective measures should be the ability to integrate individual solutions into the environment where they will be operative.

The EX-SHADWELL presents the Navy Laboratories and the Systems Commands with the capability to conduct thorough investigations and analyses that verify the problems, then propose solutions on a scale most nearly representative of the true operational environment. Scientific evaluation of short term experiments and long term studies can be conducted and controlled on board EX-SHADWELL that would not be practical on an operational ship.

Shipboard personnel and the training community have been influenced by two generations of relatively little combat experience. Although we have experienced disastrous fires, fires under combat conditions present a different set of priorities and challenges. Fully integrated damage control tests aboard EX-SHADWELL can be conducted under very realistic (but safe) scenarios, including the use of fleet personnel. These tests would provide more than scientific data for the RDT&E efforts; we would also develop a renewed way of thinking and a pool of experienced operators and trainers that could return to their commands and instill realism into shipboard exercises with credibility.

Operational Test and Evaluation Force (OPTEVFOR) is tasked with performing Operational Evaluation (OPEVAL) of Damage Control items prior to fleet introduction. Duplicating the damage scenario for testing aboard active ships has of necessity been done through imagination and simulation. Even the limited facilities ashore at the training centers are restricted to much less realism than attainable in EX-SHADWELL. Therefore, testing and evaluation by OPTEVFOR on EX-SHADWELL would approach the realism that would be expected on an actual operating ship in the fleet.

Damage control responsibilities are assigned to many personnel in the supporting community ashore; OPNAV sponsors, NAVSEA program managers, technical directors and life cycle managers, RDT&E laboratories, NAVSUP, NAVAIR, and various other line and staff billets. More often than not, these assignments are collateral duties (as is shipboard damage control) in which the incumbents may not have full appreciation for the demands of damage control, its execution and under what conditions. While the mission of the Navy in peacetime includes preparation for war, many damage control preparations are now being made based on recognized needs that have evolved from primarily peacetime casualties. The need for wartime realism is critical, and with the EX-SHADWELL as the advanced damage control test ship, the opportunity for on-site tests and visits and education of responsible personnel would be readily available and encouraged.

Fleet personnel are sometimes faced with technical questions for which they have difficulty finding the answer or locating technical expertise. With EX-SHADWELL being a focus of information relative to damage control and the close association maintained with the technical authorities, information flow to and from fleet users can be simplified and expedited.

The possibilities for the EX-SHADWELL are almost unlimited. One of the most useful will be integrated tests to simulate enemy actions with multiple casualties, ships force, damage control parties, and ship systems. For these reasons it is important to maintain the ship systems that will play a key role in damage control such as ventilation, lighting, fire mains, fire pumps, and internal communication. Spectacular fires that yield very little data are not envisioned, but large fires which may on occasion appear to be out of control can be set by proper planning, programming and control. One real advantage of the use of the EX-SHADWELL is that individual tests can be highly instrumented and controlled for acquisition and processing of data, in real time and later. This makes tests much more useful in the long run in that knowledge gained and lessons learned can be applied to a variety of scenarios over and beyond the specific questions posed by the particular test in question, particularly if that test is an attempt to only duplicate the conditions of a particular accident.

CAPABILITIES/OPPORTUNITIES

The overall capabilities of the EX-SHADWELL can be organized into various categories, but for the purpose of this report it is divided into seven areas. These are: Passive Fire Safety (Fire Hardening) [1.0]; Damage Control Systems/Equipment [2.0]; Damage Control Procedures/Doctrine [3.0]; Baseline Burns for Generic Spaces [4.0]; Fire Protection/Chemical, Biological Interface [5.0]; Personnel Protection [6.0]; and Training Scenarios [7.0]. Many of the tests can be overlapped to make tests more realistic and reduce costs. No priorities are implied by the listing order of the categories or how the tests can be superimposed. For the immediate future the ship has been tentatively divided into test zones and control areas. This is presented in Appendix B.

1.0 *Passive Fire Safety (Fire Hardening)*

Passive Fire Safety (Fire Hardening) deals primarily with materials currently on board, materials being introduced into present ships, and materials proposed for ships. It also includes the amounts, geometry and types of combustibles, and spatial and air control arrangements. The key to the program will be integrating into the tests the ship systems and arrangements that will directly impact fires, such as ventilation (or alternate air supplies) and geometry, as well as fuel load and composition. Categories of passive fire safety include working fluids, low pressure air, paints and coatings, light weight fire insulation, cermets, composites, paint thickness, outfittings and furnishings, clothing, retrofit package development and exterior coatings. These subjects are further described in Appendix C.

2.0 *Damage Control Systems/Equipment*

Fires cannot be totally prevented, and as long as ships must "Go in Harm's Way," there will be fires that will require <u>active fire fighting</u> efforts. Listed in this section are systems and techniques that will decrease the response time to fires and thus substantially increase the probability of keeping damage to a minimum. This can have a real impact on fleet readiness in the event of a fire. Categories of Damage Control Systems/Equipment include fine water mist, hull communications, WIFCOM, damage control central, infrared imager, smoke curtains, smoke removal, fire detectors, helo crash/well deck fuel fire, sprinkler, post Halon decontamination, creeper for fire fighter and smoke eater. These subjects are further defined in Appendix C.

3.0 *Damage Control Procedures/Doctrine*

In the past, the actual testing of <u>Damage Control Procedures/Doctrine</u> was difficult to conduct or fine tune. Information from actual shipboard fires is sometimes hearsay and on

occasion can be quite emotional with limited hard data. Also, in the past doctrines have been developed largely from fires of the past. The testing of such doctrines has also been limited to training centers or dry runs on ships. The EX-SHADWELL will now permit the evaluation of Procedures and Doctrine integrated in other ship functions with real fires. Currently doctrine is tested at fire training schools involving two fire parties in very limited space. With the EX-SHADWELL the doctrine can be tested with DC Central, Bridge, DC lockers and fire parties. In addition, the ability to maintain vital ship functions can also be evaluated during a fire scenario. Not only can the actual fire fighting phase be thoroughly documented, the post fire cleanup, gas removal and return to combat readiness can be evaluated. The use of Halon, water or AFFF from initiation of system to post-fire return to normal can be evaluated. Doctrine for generic spaces can be developed. Attention can be paid to smoke ingestion and emergency ventilation line-up. The use of Halon for vital spaces and combat spaces can be evaluated under multi-threat conditions.

4.0 *Baseline Burns for Generic Spaces*

A series of certification or documentation burns for generic spaces can be conducted. The objective of these generic burns is to obtain information on fire behavior of material systems in well instrumented fire tests. These data will be used to upgrade training, develop "safety-grams" from the Navy Safety Center and update ships documentation. With minor modifications the tests can all be performed on the EX-SHADWELL. Spaces for testing include machinery/boiler, pump room, hangar bay, helo-port, berthing, command/control/communication, galley, stowage/store room, passageways, oil mist, remote build-up of combustible gases, fire/flooding/CPS zones, modeling, flammable liquid lockers, weapons/magazines/weapons elevators, and chimney/duct fires. These are further described in Appendix C.

5.0 *Fire Protection/Chemical, Biological Interface*

Damage control also encompasses setting conditions to limit the spread of chemical and biological agents. Under enemy action, damage control could very easily involve both fire and collective protection systems (CPS). Since the EX-SHADWELL will have installed three zones of CPS, experiments/tests can be conducted on both simulated agent attack and fire. Some of the areas of specific interest include detectors/sensors, fire and CPS interactions, smoke control, compartment tightness, decontamination (interior and exterior), and fire in zone and in next zone. Further information on these subjects can be found in Appendix C.

6.0 *Personnel Protection/Toxicity*

Integrated with all the test programs is Personnel Protection. There is room for improvement in all categories of this -

visibility, communication, protective clothing, and artificial environment. Subjects to be addressed in this area include oxygen breathing apparatus, clothing, communication, raingear, escape and rescue, cooled fire suits, and IR imager. Further description can be found in Appendix C.

Toxicity of products such as the particulates in smoke and gases and vapors generated in Navy fires is of growing concern, particularly with the increasing use of synthetic materials. It is a subject that needs better understanding and definition. Further discussion is also found in Appendix C.

7.0 *Training Scenarios*

Updating training courses is often dependent on actual shipboard fire experience where little instrumentation data are available. Making use of hard data and video from EX-SHADWELL tests will be invaluable to the training community. This will allow a full integration of man, equipment and ship systems. By having this level of the testing conducted by fleet personnel, data can be collected to determine the effectiveness of the equipment and procedures. Training aids can be proposed and developed by closely monitoring the reaction of ship crews to various situations. Finally, more realistic simulations from both a software and hardware point of view can be developed.

ADMINISTRATION

The EX-SHADWELL is available primarily to the SYSCOMS, LABORATORIES, OPNAV, FLEET and SAFETY Center for conducting full scale damage control tests and experiments. Scheduling of tests should be done as far in advance as possible, preferably when funding documents are put in place, which could be several years in advance, at the very least, two months in advance. This does not preclude taking advantage of an on-going test through augmentation, provided funds are available. Also, the augmentation should not interfer with original test objectives. Funding for each test must be provided by a sponsor. Funds for maintaining the EX-SHADWELL are provided by NAVSEA 05R23 to the Navy Technology Center for Safety and Survivability, Naval Research Laboratory, the custodian for the EX-SHADWELL. Detailed test plans will be developed by the experimenter or NRL, if desired by the sponsor, for implementation by NRL/Coast Guard or by the experimenter directly with consultation from NRL's EX-SHADWELL Technical Director. Personnel safety and consideration for safety must be considered at all times. The NAVSEA test bed sponsor is Mr. Carl Pohler, SEA 05R23 who will resolve priority differences when such problems arise. Examples of test plans for both passive and active firefighting are provided in Appendix D.

Test plans must be complete, materials must be on hand and monies resolved before a test program can begin.

APPENDIX A

Joint Research Agreement

AFN 56452

U.S. Department of Transportation
United States Coast Guard

Commandant
United States Coast Guard

Washington, DC 20593
Staff Symbol G-DMT-3/54
Phone (202) 426-1023

3308.8/06730

23 SEP 1985

From: Commandant
To: Commander, Naval Sea Systems Command

Subj: UNITED STATES COAST GUARD/UNITED STATES NAVY JOINT RESEARCH AGREEMENT - MARINE FIRE HAZARD RESEARCH

Ref: (a) COMNAVSEA ltr 9930 Ser: 55X2/257 15 Aug 85

1. Enclosed is a signed original of the subject agreement. The cooperative efforts toward establishment of this agreement were commendable.

2. We look forward to the accomplishment of the objectives of the agreement, and an increase of Coast Guard participation in the Navy Passive Fire Safety program.

R. M. POLANT
Acting Chief, Office of Research and Development

Encl: (1) UNITED STATES COAST GUARD/UNITED STATES NAVY JOINT RESEARCH AGREEMENT - Marine Fire Hazard Research, 17 September 1985

UNITED STATES COAST GUARD/UNITED STATES NAVY

JOINT RESEARCH AGREEMENT

Marine Fire Hazard Research

1. Authority

This Joint Research Agreement (JRA) is entered into as a Memorandum of Understanding between the United States Coast Guard (USCG) and the United States Navy (USN) concerning cooperation in Research, Development, Testing and Evaluation (RDT&E) of shipboard fire protection.

2. Overall Objective

The overall objective of the JRA is to increase the effectiveness of the USCG and the USN research programs in fire protection through expansion of the USCG fire and Safety Test Detachment (F&STD) in Mobile, Alabama, and to include joint research projects, information exchange, and program coordination in the use of this facility.

3. Methods of Cooperation

3.1 General: The following methods of cooperation will be utilized under this JRA:

3.1a The USN will supplement the F&STD facility at Little Sand Island, Mobile, Alabama by incorporating a retired surface combatant as a third test ship next to the existing ships. The USN will be responsible for site preparation, including dredging in order to provide berthing for the USN ship. The USN test ship will be assigned to the Naval Research Laboratory (NRL). The environmental impact statement currently in effect for the USCG test ships will be amended by the USN to include the USN test ship.

3.1b The USN will have primary cognizance over its own ship in planning and performing tests, but will closely coordinate all testing with the USCG Research and Development Center, Groton, Connecticut. The overall F&STD complex will be under the control of the USCG.

3.1c Both parties will exchange operational and assessment data and participate in the definitional phase of experimental facility planning.

3.1d Both parties will exchange reports embodying significant research results from their activities subject to restrictions on distribution of proprietary or other sensitive data. No classified data will be handled at the site.

3.1e Researchers from both agencies will participate in workshops and conferences by the USCG or the USN to address specific marine fire protection issues and to provide a mechanism for the formal/informal exchange of information.

3.1f Both parties will cooperate in studies to evaluate the benefits and cost of potential applications for marine fire protection research.

3.1g Researchers from both agencies will be invited to inspect experimental test facilities and to witness and/or participate in tests related to marine fire protection.

3.1h Both parties will exchange any developed software packages for studying the performance and operation of fire protection devices or methods.

4. Project Officers

4.1 Designation:

FOR U.S. NAVY

Primary Project Officer:	Technical Project Officer:
Director, Fire Protection Division Naval Sea Systems Command Washington, D. C.	Head, Combustion Section Naval Research Laboratory Washington, D. C.

FOR U.S. COAST GUARD

Primary Project Officer:	Technical Project Officer:
Chief, Marine Technology Division, Office of Research and Development Washington, D. C.	Chief, Marine Fire Research Branch, USCG Research and Development Center Groton, CT

4.2 Responsibilities - The Primary Project Officers will be responsible for general administration and informing their respective agencies of accomplishments and the overall effectiveness of this JRA. The Technical Project Officers will be responsible for achievement of objectives of this JRA and will be the principal point of interface between the parties. An on-scene test director, for each test series, will be designated by letter from the USCG Technical Project Officer and so specified in each test plan.

4.3 Coordination Meetings - Coordination meetings will be held at least annually to familiarize the Primary Project Officers with the status of activities. The meetings will be held alternately at NRL and R&DC.

4.4 Reporting - The Technical Project Officers will prepare a joint annual report to the Chief, Office of Research and Development; Commander, Naval Sea Systems Command; and the Chief of Naval Research reporting the results of meetings and progress achieved.

5. Financial Arrangements

5.1 The USCG will charge to the USN the full cost for use by the USN of the F&STD including, but not limited to the use of USCG test ships, USCG personnel or USCG equipment and associated facilities except as indicated in paragraph 5.3.

5.2 The USN will charge to the USCG the full cost for use by the USCG of the USN test ship, USN personnel or USN equipment except as indicated in 5.3.

5.3 For test projects of mutual benefit to the USCG and the USN, cost sharing will be proportioned to each in an amount equal to the benefit received as agreed to in advance. Either party has the option to withdraw from a project if funds are not available, provided that on-going task sharing or cost sharing projects will be completed in accordance with original terms and schedules.

5.4 Funds shall be transferred sufficiently in advance of testing to permit the timely purchase of all supplies and materials necessary to conduct the tests.

6. Disclosure of Information

Both parties will make clear to all manufacturers cooperating with any specific agenda item that all information provided at the review meetings will become publicly available, except to the extent that either party requests that the information not be made available to the public; and to the extent that withholdiing such information is consistent with public law.

7. Liability

7.1 Facilities - Tests plans will be mutually agreed to for the safety of personnel and equipment. The on-scene test director will conduct all tests and may terminate any test for technical reasons. A safety observer will be assigned by the supervisor of F&STD for each test series. The safety observer may terminate any test for significant safety reasons. NRL through the USN Technical Project Officer will be responsible for the USN test ship and ancillary equipment except where overall safety of the general facility is concerned. Any placement or removal of equipment on the USN ship must have prior approval of NRL, in addition to approval of the supervisor of F&STD. The overall safety of the F&STD facility resides with the USCG.

7.2 Technical Data - The parties will make a best effort to ensure the accuracy of all data, but the accuracy of such data is not guranteed. Each party will use the other's data at its own risk and may not hold the other party responsible in the event of claims arising out of the use of said data.

7.3 Navy Ship Disposition - It is anticipated that after ten years, use of the USN ship as a test platform will end. In the event that disposition includes removal from the berthing site as described in paragraph 3.1a, said removal will be at no cost to the USCG. Any monies derived from disposition of the USN ship will be under the cognizance of the Chief of Naval Operations.

8. Duration of Agreement

This agreement shall enter into force upon signature and remain in force until terminated by either party upon written notification, provided that on-going task sharing or cost sharing will be completed in accordance with their original agreed terms and schedules.

9. Amendments

This JRA may be amended at any time by mutual agreement in writing.

AGREED:

FOR THE UNITED STATES NAVY

M. V. Ricketts

RADM M. V. RICKETTS
Deputy Commander
For Ship Design and
Engineering
Naval Sea Systems Command

Date 14 August 1985

J.B. Mooney

RADM J.B. MOONEY, JR.
Chief of Naval Research

Date 8·26·85

FOR THE UNITED STATES COAST GUARD

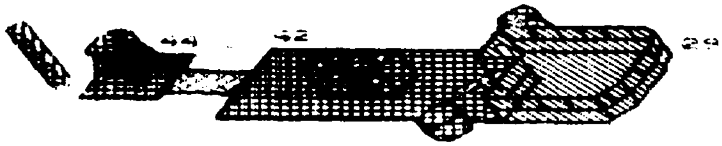
H.B. Thorsen

COMO H. B. THORSEN, Chief
Office of Research and Development

Date 17 Sept 1985

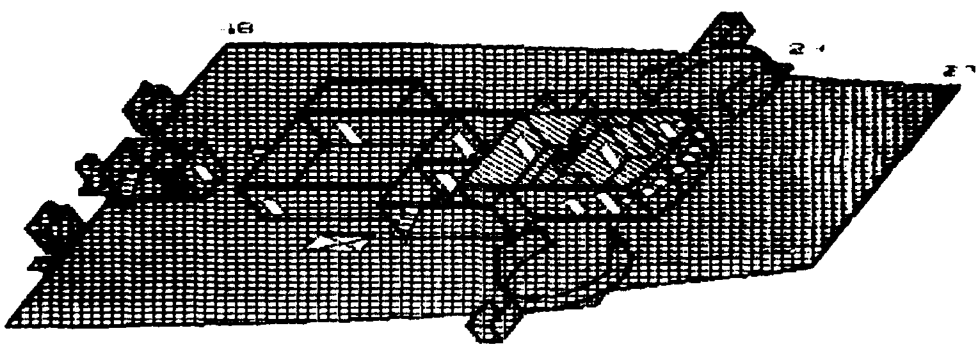
APPENDIX B

EX-SHADWELL's INITIAL TEST ZONES



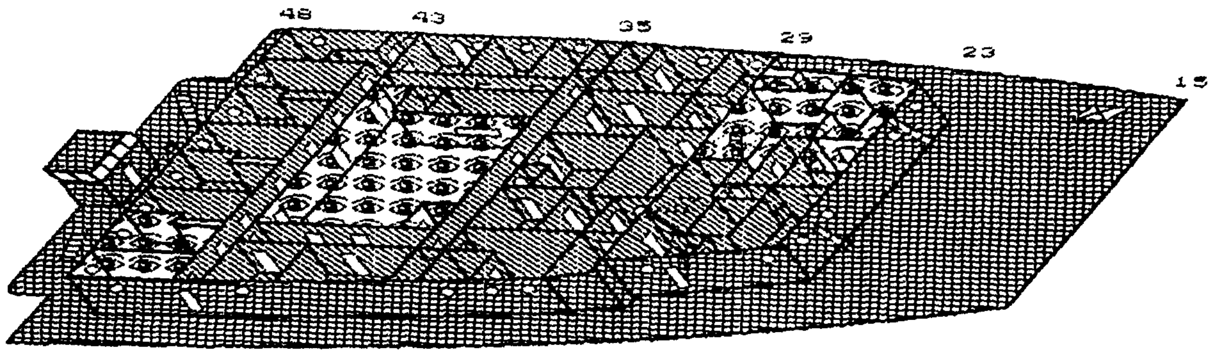
04 Level

UNLIMITED TESTING
TESTING WITHOUT FIRES
LABORATORY CONTROL SPACE



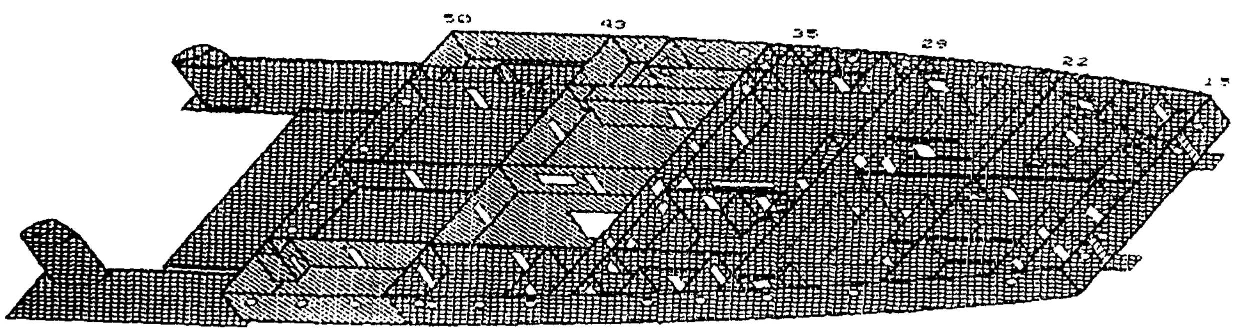
03 Level

UNLIMITED TESTING
TESTING WITHOUT FIRES
LABORATORY CONTROL SPACES



02 Level

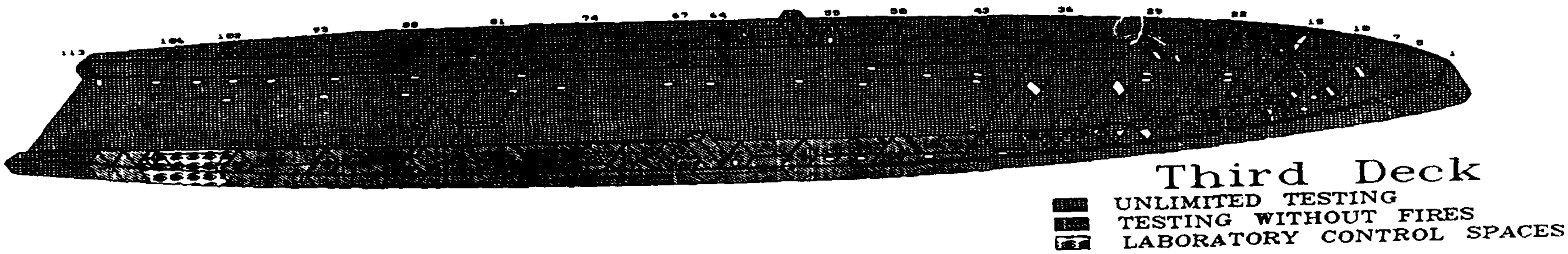
UNLIMITED TESTING
TESTING WITHOUT FIRES
LABORATORY CONTROL SPACES

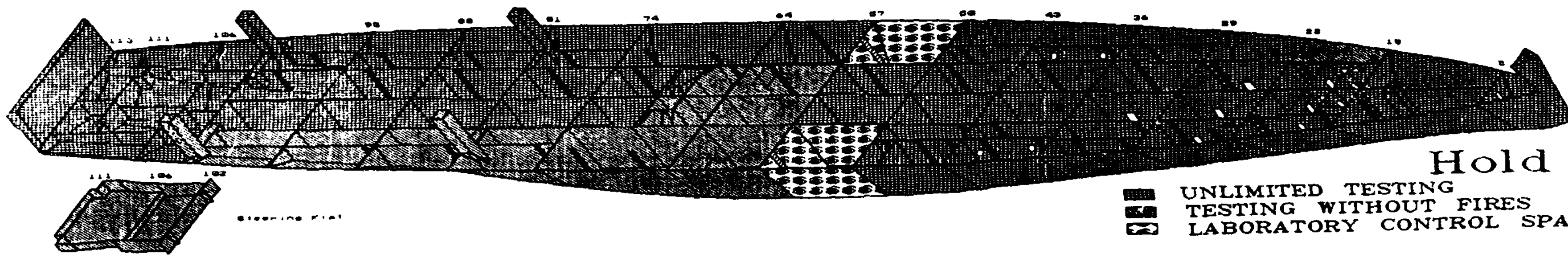


01 Level

UNLIMITED TESTING
TESTING WITHOUT FIRES
LABORATORY CONTROL SPACES


1st Deck
UNLIMITED TESTING
TESTING WITHOUT FIRES
LABORATORY CONTROL SPACES
Second Deck
UNLIMITED TESTING
TESTING WITHOUT FIRES
LABORATORY CONTROL SPACES


Third Deck
UNLIMITED TESTING
TESTING WITHOUT FIRES
LABORATORY CONTROL SPACES


Hold
UNLIMITED TESTING
TESTING WITHOUT FIRES
LABORATORY CONTROL SPACES

APPENDIX C

EX-SHADWELL'S TEST OPPORTUNITIES

CONTENTS

CONTENTS (continued)

1.0 *Passive Fire Safety (Fire Hardening)*

1.1 Working Fluids

Although many of the shipboard working fluids are a minor fire threat in the liquid pool state, in their atomized state they take on the characteristics of a vapor. This situation can result from small leaks in high pressure lines such as in hydraulic systems. It may be impossible to secure such systems before a significant quantity of fluid is atomized, resulting in a dual threat - explosions and three-dimensional fires. Since the likelihood of replacing these fluids in the immediate future is remote, fire fighting efforts and isolation techniques must be maximized. As more fire resistant fluids are developed they can and should be evaluated under full scale conditions.

1.2 Low Pressure Air

Since many of the shipboard low pressure air lines are 50/50 soft soldered they will readily separate in a major fire. This results in a blow torch effect which can significantly enhance fires. The noise from the ruptured line can add another level of confusion to fire fighting. The securing of the air lines may be impossible or their involvement may be unknown. In the case of submarines, the low pressure air is also used for breathing masks and cannot be secured. The impact of ruptured air lines on specific compartments and subsequent involvement of materials can be evaluated. The interference with fire fighting efforts can also be assessed and, most importantly, techniques to protect soldered joints for back fit, and whether recommendations for alternates are necessary for new construction. This task can best be conducted with fire fighting and baseline burns for generic space tests.

1.3 Paints and Coatings

Many materials on ships, such as wireways, insulation, and paint, are vulnerable to fire. Some limited degree of protection can be realized with intumescent paints through reduction of fire involvement (heat output) and fire spread. Goals for protection time should be based on fire party response time and should be studied with this in mind. The ultimate protection should be with replacement of the primary materials or if this is not possible, a protective coating. The appropriateness of coating shipboard materials such as cables can be evaluated under full scale.

1.4 Light Weight Fire Insulation

Some of the ships in the fleet have aluminum in their superstructures which, is vulnerable to fire. Insulation is used to protect bulkheads of critical spaces and other fire vulnerable materials. Rate of temperature rise for protected surfaces and compartments can be developed for spaces at various

levels in the ship as well as for superstructures. New insulations, such as open cell polyimide and glueable fiber glass, can be evaulated under full scale.

1.5 Cermets

A promising technique developed from the 6.2 R&D program uses a high temperature spray process to put a ceramic/metal coating on substrates such as aluminum. The fire hardening characteristics imparted by this coating makes it attractive for use on aluminum superstructures. Although cermets shown considerable fire retarding in the laboratory they have not been evaluated under large scale.

1.6 Composites

Composites currently have widespread application in aircraft and are attractive due to their light weight and high strength features. The most popular form in the Navy is the graphite filament with epoxy resin. The push for composites use on submarines has been for weight savings and should have widespread application on surface ships. Since the resins are organic, they can add to the fuel load. Also, in a fire, some of their smokes are electrically conducting. Their proposed structural and load bearing applications makes full scale fire testing extremely important. In addition, very little is known of the fire and toxicological characteristics of composites.

1.7 Paint Thickness

Thin coats of paint have a degree of fire hardening on metal substrates due to heat adsorption, as opposed to non-metal substrates. As the thickness of the paint builds over the years much of this safety factor is lost. In fact, at some point the paint can be considered as a layer of fuel over the metal surfaces and can contribute significantly to fire spread. This contribution has not been quantitated satisfactorily in terms of thickness and paint type. Full scale tests could yield data on when paint should be stripped, especially when anticipitating action.

1.8 Outfittings and Furnishings

Although items under this category should be controlled with specifications, material costs sometimes take precedence. The fire impact for this category of materials is not well characterized. Typical compartment configurations for messing, berthing and officers country can be evaluated under full scale where geometry and ventilation play a key role. The impact of the use of non-specification material vs specification material can be evaluated for informative training. The data can also be useful for tightening specifications.

1.9 Clothing

Both issue and non-issue clothing are carried and used aboard ships. The storage and wearing of such clothing can have a direct impact on ship readiness when fires break out under hostile action. Smoke, fire spread and toxicity are key issues with every day clothing as well as special clothing for fire fighting and chemical defense. These issues should be evaluated under full scale so impact can be assessed and recommendations made to increase fleet readiness.

1.10 Retrofit Package Development

In some instances the solutions from the R&D community to the Systems Commands do not reach the users because there is a lack of complete documentation for implementation into the fleet hardware and software. Proposed new damage control equipment, materials and software can first be installed on the EX-SHADWELL to assure a ship alteration package is complete and has the damage control aspects desired.

1.11 Exterior Coatings

The fire vulnerability of lightweight armor and coatings which decrease a ship's detectability should be evaluated full scale before implementation into the fleet. Small scale laboratory tests will not predict the impact of full scale involvement. Testing of such coatings and armor under full scale will determine ship vulnerability to fire.

2.0 *Damage Control Systems/Equipment*

2.1 Fine Water Mist

Conceptually, the fine water mist system is a fixed suppression system which takes advantage of the heat capacity of water by delivering to a fire the suppressant in an optimal physical state and geometry. This requires a minimum amount of water and thus eliminates some of its deleterious side effects. This fixed system is under development for selected submarine compartments and should be expanded to the surface fleet. Vital cableways and high risk spaces protected with water mist can be tested for fire vulnerability on the EX-SHADWELL. Based on data collected, military specifications could be developed for specific fixed systems.

2.2 Hull Communications

The use of the ship's structure as a communication medium has exciting possibilities. This almost non-destructible link between damage control central, damage control lockers and fire party can be installed and tested on the EX-SHADWELL. This

would allow the testing of the systems hardware and software under actual fire/fire fighting conditions with other equipment and ship systems operating.

2.3 WIFCOM

Although wire free communication already has some limited experience in the fleet, this experience can be increased markedly by incorporating WIFCOM in the fire fighting tests conducted on the EX-SHADWELL. The data gained in its uses and limitations would be helpful in training and improvement programs.

2.4 Damage Control Central

An automated damage control central with the integrated use of mini-computers, WIFCOM, HULL COM can automate damage control to the extent that technology in Central will come abreast of the 20th century. As systems and software developments occur, they can be evaluated in the EX-SHADWELL with other fire fighting/damage control tests. Doctrine, training and other technical data developed can be utilized to improve fleet readiness. Information handling and assessment with subsequent recommendation in short periods of time are an emerging science. Taking advantage of this opportunity at critical times on shipboard is extremely timely.

2.5 Infrared Imager

Although the IR imager is being procured for the fleet, very little critical fire data are available on it. When opportunities arise with various tests on the EX-SHADWELL the imager should be used. The data on the imager can be documented and supplied to the proper codes in NAVSEA, training community and Safety Center for improved use of the system.

2.6 Smoke Curtains

Curtains of two kinds are envisioned: fixed and portable. Portable curtains are designed for doors, hatches and passageways for use in conjunction with fire fighting efforts and desmoking. The fixed curtains can be deployed as needed or when general quarters are set to maintain major smoke boundaries. Specifications for curtains and doctrine for their uses can result from the EX-SHADWELL program. After initial tests, the smoke curtains can be used in conjunction with other tests for fully integrated damage control efforts.

2.7 Smoke Removal

If possible, smoke removal would be best accomplished by ventilation lineup. However, when not possible, portable blowers along with smoke curtains can be used to optimize smoke

removal, including post fire cleanup procedures. Ventilation-lineup using supply and exhaust for desmoking can be optimized so guidelines can be developed to desmoke in minimum time.

2.8 Fire Detectors

Specifications for a shipboard fire detection system are nearing completion. At least one or more zones of detectors can be installed on the EX-SHADWELL as this will give the Navy an opportunity to evaluate the systems under actual shipboard fire situations. Problems that may arise in the fleet can then be duplicated and solved quickly. Additionally, background data collected on the detectors in conjunction with other fire test data will allow another improved generation of detectors to be developed.

2.9 Helo Crash/Well Deck Fuel Fire

If shipboard testing is necessary after the large scale land tests at China Lake, the EX-SHADWELL has a helo pad and well deck available which makes the simulation of this event possible. Doctrine covering rapid response with various fire fighting techniques and specifications for fixed systems can be developed.

2.10 Sprinkler

Except in high risk areas, such as weapons magazines and hangar-bays, the Navy uses very few sprinkler systems on its ships. On larger ships it may be appropriate to sprinkle major cableways, large store rooms or other selected spaces. Vital space perimeter sprinkling may also be an option worth evaluating in a shipboard environment. Full scale evaluation can determine the practicality and aid in developing specifications. The possibility of mixing halon with water sprinklers for selected spaces can be evaluated on full scale.

2.11 Post Halon Decontamination

The use of halon results in production of acid gases. Also produced in some cases is a teflon-like coating, which reduces electrical conductivity and can trap acids making decontamination difficult. Methods of decontamination and post fire cleanup need to be addressed. Full scale testing can be useful in determining the practicality of developed methods.

2.12 Creeper for Fire Fighter

The cable fire fighting tests have shown that spraying with water ahead of a fire party may not be the best fire fighting technique if bulkheads and upper layer air temperatures in the passageways are high. Under these circumstances the water protection tends to flash to steam, creating an additional hazard. Since entry by duck walk or crawling may be a better

option, a lightweight creeper device would be of benefit for the advance fire party. This can be incorporated into a fire fighting test as a piggyback experiment.

2.13 Smoke Eater

The incorporation of collective protection systems into ships will alter smoke removal procedures. Self-contained smoke removal devices, as opposed to use of ship's ventilation, may be necessary. Catalytic/filtration system can be evaluated full scale to determine their practicality.

3.0 *Damage Control Procedures/Doctrine*

No further breakdown at this time.

4.0 *Baseline Burns for Generic Spaces*

4.1 Machinery/Boiler Space

Machinery/Boiler space on the EX-SHADWELL are on both the port and starboard side. The port side has been designated the hot burn side and the starboard side as the control and cold smoke side for the initial testing phase. The port engine room involves three decks with expanded metal deck coverings. It is reached through vertical shafts extending down two decks. For fire fighting tests an additional door into the well deck would be installed for safety use only during an emergency. Main space fire fighting doctrine can be evaluated as a follow-on to the certification burns.

4.2 Hangar-Bay

The EX-SHADWELL does not currently have a hangar-bay, but the well deck extends forward of the superstructure. A hangar door can be installed in this area. Three formal zones of CPS are planned for the EX-SHADWELL. Two of the zones require a partition in the well deck. This should result in at least one, and possibly two, discrete hangar-bay type areas.

4.3 Helo-Port

The EX-SHADWELL was the first LSD to conduct helicopter exercises and is equipped with a helopad. Simulated crashes and fuel spills on the helopad with running fuel spills into the well can be simulated. As follow-on to the certification burns, a series of fire fighting tests can be conducted.

4.4 Berthing

The EX-SHADWELL has diverse berthing areas. There are ships force berthing and also berthing for embarking troops. The racks and lockers are in place making these areas ideal for berthing space fire tests.

4.5 Command/Control/Communication

These spaces are in the superstructure and would best be benefited by studying the effects of smoke and protection of vital spaces. In integrated tests these spaces could be manned for realistic communication simulation.

4.6 Galley

The EX-SHADWELL is equipped with a galley capable of preparing food for the whole ship. It has diverse equipment still on board and almost any kind of galley fire can be simulated. Two fires proposed are Class B in the deep fat fryer and Class C in ovens or stoves.

4.7 Stowage/Store Rooms

There are numerous store rooms below deck for fire tests. Some are entered through hatches and some are located off passageways. For fire fighting tests both methods of entrance can be employed.

4.8 Passageways

Passageways with cable bundles in the overhead can be found on the second level. There are also thwartship passageways in the superstructure. Certification burns can employ all these areas.

4.9 Oil Mist

Oil mist fires can be catastrophic (BENNINGTON, 1954). Different types of oil mist fires can be simulated in many areas of the ship. Initially they can be created in the port wing wall.

4.10 Remote Buildup of Combustible Gases

This test can be performed almost anywhere on the ship, but must be planned well to avoid explosions. The concern is that unburned gases from one fire could collect in an area remote from a fire, mix with fresh air and create a highly explosive mixture. Fires below decks generally burn very fuel rich with large amounts of unburnt gases being created and released. Tests can be planned so that flammable vapors can be generated under controlled conditions in a variety of spaces and environments, and their behavior monitored and studied.

4.11 Fire/Flooding/CPS Zones

The EX-SHADWELL has or will have all three types of zones. One additional consideration should be given to smoke zones. Large scale tests can be conducted with and without active fire fighting to contain and control fire, smoke and flooding.

With diverse instrumentation a large data base can be collected for the first time for multi-level multi-compartment involvement. Valuable information can be collected on personnel protection items and smoke curtains for incorporation into training and future design.

4.12 Modeling

Commensurate with the experimental program involving the EX-SHADWELL will be a modeling program. It is recognized that full scale testing for each scenario may not always be possible, especially a number of years from now. Therefore, a modeling program in conjunction with the experimental program is vitally important. Each major test can have the involvement of the modeling program. If the modeler is involved in test planning, it insures that data necessary for the modeling effort will be acquired in the major tests. This must be a give-and-take effort.

4.13 Flammable Liquid Locker

There are two flammable liquid lockers on the EX-SHADWELL which are equipped with fixed CO_2 systems. Halon with 1211 or 1301 can also be tested as suppressants for these lockers. Electrical cable penetration into such spaces have been viewed as creating weak links in multi-cable transits in the event of a rapid combustion process and overpressures. One of the flammable liquid lockers can be used to determine the "explosion proofing" required for these spaces.

4.14 Weapons/Magazines/Weapons Elevators

These spaces are available on the EX-SHADWELL and the vulnerability of these spaces to fires in adjacent compartments can be evaluated. Fixed suppression systems and detection systems within the spaces can be evaluated. Instrumented weapons simulations can be placed in the compartments.

4.15 Chimney/Duct Fires

Buildup of grease and dust in ducts can lead to a significant fire spread problem. The extent of this shipboard hazard can be evaluated.

5.0 *Fire Protection/Chemical, Biological Interface*

5.1 Detectors/Sensors

Fire detectors and CW/BW sensors will be new to the fleet. The interaction of the two concepts with each other and with ship systems should be anticipated. Integrated tests involving the CPS, detectors, simulated attacks and fires can be assessed in full scale. Data collected can demonstrate the reliability

of the systems. Today's commercial fire detectors tend to false alarm. In fact, false alarm is a tradeoff with sensitivity of the detector - the more sensitive you make the detector the more false alarms. This test program can allow for optimization of the detectors and sensors. Sensors should also be coupled with Damage Control Central and Communications studies.

5.2 Fire and CPS Interaction

The effect of fire on CPS will tax the ventilation fans, require by-pass filters and fan reversibility for desmoking. Under actual combat conditions, both fire and CBW can be expected and must be prepared for in training. Data collected under the dual threat could result in the development of training situations and improvement of design. This test program could also result in redesign and design for retrofit of CPS (e.g. vertical flow systems). Testing with the dual threat will allow the air quality throughout the ship to be evaluated.

5.3 Smoke Control

Problems associated with smoke generation and motion in operating and CPS systems need definition. Control and removal of smoke in such systems, can be studied either independently or in connection with other on-going tests.

5.4 Compartment Tightness

Compartment tightness will be key to flooding, smoke spread and containment after casualty. Just how important compartment tightness is to combat readiness is not known (leak rate). With the EX-SHADWELL a tightness factor can be developed.

5.5 Decontamination Exterior and Interior

Full scale shipboard tests can be conducted to determine the effectiveness of current techniques. The effect of breach in CPS and its effect on DC can be tested. The rate of decontamination can also be studied. Simulants for training can be evaluated on an actual ship to determine their effectiveness.

5.6 Fire in Zone and in Next Zone

Fire tests will be conducted within a zone and in adjacent zones to determine the effects of overpressure from the fire. Large scale conflagration may play a role in monitoring CPS and thus overall combat readiness. Fully integrated tests involving smoke removal can be conducted.

6.0 *Personnel Protection/Toxicity*

6.1 Oxygen Breathing Apparatus (OBA)

In almost every major shipboard fire, a problem arises with the OBA whether it be a sealing problem or lifetime of the canister. If these problems are real, it will require hardware modification, or if perceived, will require change in training. Fully integrated fire fighting tests can be conducted to determine realistic limitations of the OBA. Improvements in the OBA can also be evaluated.

6.2 Clothing

Advanced protective clothing for the fire fighter is not currently available in the fleet. A program is underway to introduce special suits in the fleet. These can be integrated with other tests to determine if the proposed clothing should be modified for shipboard use.

6.3 Communication

Communication remains a problem throughout the entire link from scene leader to nozzle man, back to the repair locker and DC central. Systems such as WIFCOM, touch signals and HULL COM can be evaluated for various fire situations. Recommendations for training, improvement and integration with other equipment can be made.

6.4 Raingear

Cable fire fighting tests showed that raingear was strategic to rapid extinguishment of cable fires. Steam created in the fire fighting was debilitating without the raingear. Further evaluation of raingear for other types of fires can be made.

6.5 Escape and Rescue

This important facet of damage control has not been emphasized in any test program for optimization. Egress beacons and reflective tapes have been developed or partially developed. Testing under realistic conditions has not been accomplished. A test program with generic tests can be developed and evaluated. The same can be applied to guidance systems using sound.

6.6 Cooled Fire Suits

The need for this type of suit and its application can be developed during generic fire tests. Given the need, criteria for use and suit development will follow. Realistic testing of the hardware can be accomplished along with specifications and training.

6.7 IR Imager

This is currently being procured for the fleet. Its use in fire fighting tests will greatly expand our data base in its use. This information can be incorporated into training and shipboard documentation.

6.8 Toxicity

Sophisticated instrumentation is being incorporated into EX-SHADWELL for real time measurement of fire behavior. Included will be chemical analysis capability to indentify and measure particulates and gases and vapors either in real time or by grab samples for later analysis. These data can then be correlated with known toxicological data to give a realistic assessment of hazard to unprotected personnel. Such data acquisition can be coupled with a large variety of other tests, but particularly those involving new synthetic and other novel materials. The impact of burning conditions (e.g. oxygen deprivation) on fire products formed, and their potential toxicity can also be evaluated.

7.0 *Training Scenarios*

No further breakdown of this category at this time.

APPENDIX D

TYPICAL ACTIVE AND PASSIVE TEST PLANS

OUTLINE OF NAVY CABLE FIRE TEST SERIES

	Tasks	Number of Tests	Test Number
Task I.	ESTABLISH CONDITIONS (Pan fire size) Equipment Checkout (gas analyzers, Temp sensors, heat flux meters, gas samplers, smoke sensors)	3 tests	NT(W1), NT(W2), NT(W3)
Task II.	Determine Reproducibility of Test Method	3 tests	NT(W4), NT(W5), NT(W6)
Task III.	NAVY CABLE TEST	5 tests	NT(W7), NT(W9), NT(W11) NT(W13), NT(W15)
	Background Test	5 tests	NT(W8), NT(W10), NT(W12) NT(W14), NT(W16)
Task IV.	Navy Cable Protection Tests	3 tests	NT(W17), NT(W19), NT(W21)
	Background Test	3 tests	NT(W18), NT(W20), NT(W22)
Task V.	Navy Radio Frequency (RF) Cable Tests	3 tests	NT(W23), NT(W25), NT(W27)
	Background Test	3 tests	NT(W24), NT(W26), NT(W28)

I. Establish Operating Conditions

Test W1 - (1.1) Compartments configured (Al bulkheads and Steel bulkheads overhead and deck) no cables (2'x2' heptane pan, 4 gallons)

(1.2) Instrumentation - All

(1.3) Video and photographs

(1.4) Data Reduction - On site

1. Temperatures in compartments
   Individual
   Average
2. Temperatures in corridor
3. Average temperature in room of fire origin
4. Radiometers - individual plots
5. Load cell for the pan
6. CO, O_2, CO_2 - individual plots
7. Gas bottles - THA on site Anal.

Test W2 - (2.1) Compartments configured (Al bulkhead and Steel bulkheads overhead and deck) no cables (3'x3' heptane pan, 8 gallons)

(2.2) Instrumentation - All

(2.3) Video and photographs

(2.4) Date Reduction - On site

1.
2.
3. Same as Test 1
4.
5.
6.

Test W3 - (3.1) Compartments configured (Al bulkhead and Steel bulkheads overhead and deck) no cables (4'x4' heptane pan, 10 gallons)

(3.2) Instrumentation - All

(3.3) Video and photographs

(3.4) Data reduction - on site - same as for Test W1 and Test W2

II. Establish reproducibility of test method - No cables

Test W4 - (4.1) No cable (pan size to be selected)

(4.2) Instrumentation - All

(4.3) Video and photographs

(4.4) Data Reduction - On site

1. Temperature in compartments
   Individual
   Average
2. Temperature in corridor
3. Optical density in corridor
4. Radiometer - individual plots
5. Fire pan load cell
6. All continuous gas analysis on individual plots
7. Gas bottles - THA on site Anal.

Test W5 - Same as Test W4

Test W6 - Same as Test W4

III. Navy Cable Test Series

Test W7 - (5.1) Cables (MIL 915E-Preamend 2) in place

(5.2) Instrumentation - all channels

(5.3) Video and photographs - before, during, after

(5.4) Data reduction - On site
Same as Test W4 with addition of
temperatures in cable bundle

Background Test

Test W8 - Same as Test W4

Test W9 - Cables (MIL-C-915F) in place
All other parameters the same as Test W7

Background Test

Test W10 - Same as Test W4

Test W11 - (7.1) Cables (MIL-C-XXXXX & MIL-C-915F) in place
All other parameters the same as Test W7

Background Test

Test W12 - Same as Test W4

Test W13 - (8.1) Cables (MIL-915E-Amend 2) in place.
All other parameters the same as Test W7

Background Test

Test W14 - Same as Test W4

Test W15 - (9.1) All cables above [(MIL-915E-Amend 1), (MIL-915E-Amend 2), (MIL-C-915F), and MIL-915-XXXX, MIL-C-17)] in place.
All other parameters the same as Test W7.

Background Test

Test W16 - Same as Test W4

IV. Navy Cable Protection Test Series

Test W17 - (10.1) Cables (MIL 915E-Amend 1) in place.
All other parameters the same as Test W7

Background Test

Test W18 - Same as Test W4

Test W19 - (11.1) Cables (MIL-C-915E-Amend 1) in place and protected with substrate #1 (to be selected).
All other parameters the same as Test W7

Background Test

Test W20 - Same as Test W4

Test W21 - (12.1) Cables (MIL-C-915E-Amend 1) in place and protected with substrate #2 (to be selected).
All other parameters the same as Test W7

Background Test

Test W22 - Same as Test W4

V. Navy RF Cable Test Series

Test W23 - (13.1) R.F. Cables (MIL-C-17) and Power Cables (MIL-C-0915F) in place.
All other parameters the same as Test W7

Background Test

Test W24 - Same as Test W4

Test W25 - (14.1) R.F. Cables (MIL-C-17) with improved jacket and Power Cables (MIL-C-915F) in place.
All other parameters the same as Test W7

Background Test

Test W26 - Same as Test W4

Test W27 - (15.1) RF Cables with teflon insulation and florinated jacket and Power Cables (MIL-C-915F) in place.
All other parameters the same as Test W4

Background Test

Test W28 - Same as Test W4

FIRE TESTS OF NAVY COMMUNICATION AND POWER CABLE

TEST PLAN

MAY 1984

TABLE OF CONTENTS

TEST PLAN FOR FIRE TEST OF NAVY CABLES

1.0 INTRODUCTION

1.1 Background

a. The U.S. Navy is using power cables specified under MIL-C-915E-Amend 2. These cables when involved in a fire contribute significantly to the fuel load, produces vast quantities of black smoke, acid gases and toxic products.

b. Two new Military Specifications are being considered, MIL-C-915F and MIL-C-XXXXX. These specifications deal with light weight power cables which ostensively will produce less smoke, acid gas and toxic by-products when involved in a fire.

c. These new cables do not address the cable fire problem of existing ships as the cost of replacing the cables is prohibitive.

d. Protective coating or wrappings are being considered to protect cables on existing ships.

1.2 OBJECTIVE

The impact of new cables on ships personnel and systems under shipboard conditions will be assessed when involved in a fire.

a. Flame spread, bulkhead boundaries and heat load will be assessed.

b. Acid gas production will be measured, HCl, HBr, HF.

c. Toxic products will be measured, CO, CO_2, HCN, NO_x, SO_2 and others to be determined based on small scale tests. Possibilities for analysis include chlorine, phosgene, formaldehyde, hydrocarbons and other organics.

Old cables, MIL-C-915E-Amend 1, will be protected with coatings. The above same parameters (a-c) will be determined.

2.0 APPROACH

2.1 General

The forward four compartments and passageway on the starboard side of the 01 deck, after deck house, of the A.E. WATTS will be used as the test compartments for the full-scale fire tests. See Figure 1.

Alterations to these four compartments are as follows: (a) Remove the bulkhead between the center two compartments of the four to give a fire-test area approximately 16 feet square; (b) Replace the bulkhead with ¼ inch aluminum that extends from the passageway to the head between the after compartment (of the four) and the fire test area; (c) Replace the remaining bulkheads, overheads, and decks in the four compartments with ¼-inch steel.

Sprinklers will be installed in the overhead from the deck above with remote actuation capability. There will be two zones, see Figure 2.

The cables will be installed according to Navy requirements with both vertical and horizontal configurations. Directly over the fire area, cable will penetrate to the deck above using standard deck penetration. A liquid fuel fire will act as the source of ignition.

No forced ventilation will be provided but the fire compartment will be open to passageway. Since the new specifications are for light weight power cables only, each cable bundle will have to contain MIL-C-915E-Amend 2 cable to simulate the shipboard situation. These cable tests will be conducted, with MIL-C-915-E-Amend 2 ; with MIL-C-915-F; and MIL-C-XXXXX and MIL-C-915-F. Provided funds and time are available a repeat of the last test will be made adding MIL-C-17 cables.

The coatings will be evaluated on MIL-C-915E-Amend 1 and MIL-C-17 cables.

2.2 Fire Scenario

The tests will simulate a fire involving cables, the initial source of ignition being a liquid fuel fire. The source of ignition will be a n-heptane fuel fire in a square pan, the exact size to be determined in the "Establish Operation Conditon" phase . Enough fuel will be used for a 15 minute pan fire burn. The cables in the area of the simulated motor generator will be subjected directly to the pan fire.

Since the primary objectives are to determine the quantities of smoke, acid gas and toxic gases and potential for fire spread due to electrical cables, no other combustibles will be in the compartment.

The basis for comparison in this series of tests will be flame spread, toxic or corrosive by-products, and obscuration of vision.

Sequence of Events

a. Doors to passageway closed except the test compartment doors.

b. Data acquistion system started.

c. Fire started

d. Data is recorded until all fire activity has ceased.

3.0 THE TEST AREA

3.1 Test Spaces

The tests will be performed on board the tanker vessel ALBERT E. WATTS in test compartments and passageway on starboard side after deck house on the 01 level. Figure 2 shows the compartment plan. The after bulkhead of the fire test area will be aluminum. The cables will be installed according to Navy specifications with steel and aluminum open cable hangers. The same cable configurations will be used for the coatings substituting the cable type to simulate current shipboard conditions.

3.2. Environmental Control

All compartments except the test compartment should be secured and no forced ventilation will be used. Standard cable penetration will be used. The cable penetrations between compartments will be sealed with duct seal according to Navy procedure. No other special gas tight precuations will be taken.

3.3 Fuel/Ignition System

The fuel to be used is n-heptane, with the quantity being dictated by a burn time of 15 minutes. The ignition will be accomplished with a spark created from neon sign transformer. A way will be provided to fill and drain the fuel pans remotely from the weather deck for safety reasons.

3.4 Extinguishment System

The ability to terminate the fire at any time will be through deluge sprinklers in the overhead of the four original compartments and the passageway. The capability to sprinkle the fire compartment only will exist. The sprinkler (or hand lines) should be utilized only if necessary and only the absolute minimum amount of water should be used.

4.0 INSTRUMENTATION

4.1 Background Conditions

Instruments will be used to measure background environmental conditions before and after the fires. These will include:

a. Recording barometer
b. Wind direction and speed (measure also during test).
c. Humidity in test compartment
d. Outside temperature

4.2 Thermocouples (See Figure 1)

Type K, inconel-sheathed thermocouples will be used to measure air, cable bundle and bulkhead temperatures in the following locations:

a. Four vertical strings, four thermocouples per string, in the test compartment with each string having a T/C at 16", 48", 64" and 80" above the deck. Two strings will be located 12 in. from the cable penetration on the forward and after bulkhead. Two strings will be located in the door (See Figure 3). The fourth string will be 24 in. from the fire source on the center line of the compartments near the porthole.

b. Thermocouples will be placed in the cable bundle 24 in. apart in the fire room and the compartments fore and aft of the fire room.

c. Vertical strings will also be placed on the opposite bulkheads in the forward, after compartments and in the corridor. The corridor string will be 12 in. (after) from the door.

d. Individual thermocouples will also be placed on each side of the cable bundles on each side of the bulkheads (total of eight couples).

e. Two thermocouples will be over the fuel pan to monitor if it extinguishes prematurely.

4.3 Calorimeters (See Figure 2)

Calorimeters to measure total heat flux placed as follows: three calorimeters to be installed in the fire compartment near the surface of the aluminum (after bulkhead) and two steel (forward and passageway) bulkheads. These will be located mid level in the compartment.

4.4 Radiometers (See Figure 2)

a. Three radiometers to be installed in the test compartment in the after outside and inside corners at mid level, and on the deck near the center of the fire area looking up.

b. Two radiometers to be installed in forward and after compartments on bulkhead opposite the test compartment, mid level.

4.5 Air Velocity Probes

None to be installed.

4.6 Gas Analyzers (See Figure 2)

a. Gas analyzers to continuously measure oxygen, carbon dioxide, carbon monoxide, total hydrocarbons, sulfur dioxide, and nitrogen oxides from sample line inlets located 24", 48" and 72" (integrated sample) above the deck near the center line string of thermocouples in test compartment. Separate gas analyzer (integrated inlets) for separate banks of analyzers (CO, CO_2 + O_2) will be located in approximately same location in forward compartment. A gas analyzer inlet will also be in passageway outside the test compartment (complete set of analyzers).

b. Gas analyzers to continuously measure hydrogen cyanide, hydrogen chloride, chlorine and formaldehyde from two locations, test compartment, and passageway will be placed. The inlets will be integrated and located near the inlets in the above paragraph.

Analyzers

1. 3 Paramagnetic Oxygen Analyzers
2. 3 IR CO_2 Analyzers
3. 3 IR CO Analyzers
4. 2 IR SO_2 Analyzers
5. 2 NO_x Analyzers
6. 2 Calorimetric HCN Monitors
7. 2 Calorimetric Formaldehyde Monitors
8. 2 Calorimetric HCl Monitors
9. 2 Calorimetric Cl_2 Monitors
10. 2 Total Hydrocarbon Analyzers

4.7 Grab Samplers (Figure 2)

Sample flasks, 1.6 l stainless steel, fitted with solenoid valves and filters are to be placed in four locations; test compartments, forward and after compartment and passageway near the gas analyzer inlets. Three sets of three each (24", 48" and 72" above the deck) will be located for remote actuation. Total 36 bottles per test. These will be furnished by the Navy.

4.8 In Situ IR Analyzers

Hydrogen chloride and hydrogen fluoride gas analysis will be made directly in the test compartment with a light source and monochrometer located in the overhead of compartment below the test compartment. This test setup will be furnished by the Navy.

4.9 Load Cell

Load cell for the fuel pan will measure the fuel consumption rate.

4.10 Visual and Audio Recordings

a. Three visual color video cameras viewing from the corner of test compartment, after and forward compartments will be utilized.

b. An additional one color video camera viewing down the passageway will be used.

c. One IR camera will be located in the test compartment.

d. Still photographs (35 mm) will be taken before and after each test.

4.11 Smoke Characterization

a. The smoke obscuration measurements will be made in test compartment, forward and after compartment and in passageway. The locations will be midlevel near the gas inlet locations. At these points, the transmittance of light issuing from a low-powered laser emitter (0.5 mw, 0.632 μ wavelength) will be measured by a photo-diode detector 36" from the laser. To avoid inaccurate readings from the temperature-sensitive detector units, they will be located on the deck below the test level. Laser light at the 36" distance will be transmitted through fiber optic cables.

b. An automated impactor will be used to characterized the particle distribution in the test compartment. Samples will be transmitted to the deck below through ¼" teflon line where the analyzer will reside.

5.0 PRE-TEST FACILITY AND EQUIPMENT CALIBRATION

5.1 Remove bulkhead between center two compartments to give fire test area 16 ft x 16 ft. Remove the after bulkhead of fire test area and replace with aluminum sheathing ¼ inch thick. Remove all other bulkheads and replace with steel. If the deck and overhead are not steel, these will have to be replaced also.

5.2 Prepare opening for cable bundle and block off for fire pan size tests and repeatability pan fire tests.

5.3 Check decking and overhead for integrity and repair as necessary.

5.4 Install sprinkler system

5.5 Familiarize operating personnel with calibration and operation of all analytical equipment.

5.6 Verify operation of all analytical equipment

5.7 Install, clean, dry and seal teflon all gas analyzer lines. Gas analyzer lines in test compartment will be stainless steel and monel for HF and HCl

5.8 Install remote actuation power for grab samples.

5.9 Determine delay time to analyzers.

5.10 Install brackets for special IR equipment below the fire compartment.

5.11 Install fuel pan ignitor and feed and drain lines.

5.12 Using the base line test, establish the time-temperature curves for the fuel pans/compartment.

6.0 TEST PROCEDURE

6.1 Test Preparation

All instruments will be calibrated and checked. All personnel taking part in the test will be briefed on their respective roles. All doors to the test area and inside the test area will be closed and sealed if necessary. Video tape recordings and 35 mm photographs will be made as necessary to document the appearance of the test compartment, specimens, and instrumentation prior to each test.

6.2 Baseline Tests

Several baseline tests will be conducted with full instrumentation. No cables will be installed and cable feed-throughs will be sealed. The fuel pan size and reproducibility of fires will be established. Background test without cable will be run between each test.

6.3 Commencement of the Test

Prior to actual lighting of the pan, all instrumentation will be turned on and scanned for at least five minutes. The scan-time of five minutes will be used to establish baseline measurements. The pan will be fueled three minutes into the scan time, the level determined by video and premeasurement. The pan will be lighted. The timing clocks will be started at the instant the fuel is lighted. That instant will be time zero. The time the cables become involved will be recorded.

6.4 Data Acquisition

Data collection will be accomplished in the instrumentation trailer located on board an LCM moored beside the test vessel. Wire leads and gas sampling tubes from the instruments will be led from the test area to the deck below and then to the trailer. One exception will be the gas sample lines for the five

toxic gases that will be tested by calorimetric tubes. These lines should be kept as short as possible and the instrumentation located in close proximity to the pick-up points.

6.5 Termination of the Test

The test will be terminated when all fire activity ends or at any other time that may be decided on by the test director. The test will also be terminated, if the fire threatens the sprinkler barrier or for any other reason if the test director or the F&STD Supervisor judges that safety of the personnel is threatened.

At termination, fuel will be drained before personnel go into the test area. When the corridor temperature has dropped to about 120°F, the oxygen level has returned to normal, and the toxic gas concentrations in the corridor have dropped to traces, personnel using breathing apparatus and carrying portable water extinguishers and a backup hand line will enter the corridor and test compartment. Any smoldering embers will be extinguished using a minimum amount of water from the portable extinguishers. Remains of the test specimens should be disturbed as little as possible prior to inspection and photographic documentation.

The sprinkler systems or backup hand lines will not be used to extinguish the fire unless absolutely necessary, to avoid damaging instrumentation.

Before moving the remains of the test specimens, observations on the conditions inside the test compartment will be recorded, and videotape recordings and 35mm color photographs will be made to provide a record of the appearance of the specimens after the tests. The remains of the specimens will then be removed and the test compartment will be cleaned up and made ready for the next test.

6.6 Eight fire tests involving cables are planned: one test each with MIL-C-915E-Amend 1, MIL-C-915E-Preamend 2, MIL-C-915F, and MIL-C-XXXXX cable; then, one test will include all of the above cables; and finally, the last three tests will include a repeat test of MIL-C-915E-Preamend 1 cable, a test with MIL-C-915E-Amend 1 cable protected with substrate #1 (to be selected), and the final test with this same cable protected with substrate #2 (to be selected).

7.0 SAFETY

7.1 Safety Responsibilities

Safety of the personnel is of paramount importance throughout preparation and testing. The F&STD Supervisor is the safety officer for all operations relating to the testing. The Test Director is responsible for the technical aspects of the tests. A test will be postponed, or, if in progress, terminated,

if at any time the F&STD Supervisor or the Test Director decides that the safety of any person is threatened.

7.2 Hazards From Explosive Mixtures

An imporatant safety hazard is that liquid n-heptane might remain unburned which could evaporate and form an explosive mixture with air inside the ship. To avoid such a risk, a hydrocarbon detector and an audible alarm unit will be installed in the main deck area (the level below the test compartment) through which the fuel supply pipe runs. In the event of a leak in the main deck area, the hydrocarbon detector will actuate the audible alarm. The alarm is loud enough to warn personnel in the test area of a possible buildup of an explosive gas concentration, so that the fuel can be drained immediately and the test terminated.

The hydrocarbon gas analyzer in the instrumentation trailer will continuously monitor the concentration of hydrocarbon gas (HC) at the location of the gas sampling tube pickups in the test area. The computer will be set so that if HC concentration exceeds 2100 ppm (about 20 percent of the lower flammability limit (LFL)), an audible alarm will be sounded and the heptane drained, terminating the test.

During the test, the test compartment will be observed via the video monitor and IR camera.

7.3 Hazards From Toxic Gases

The analyzers shall be kept in operation after termination of the test. No one shall enter the test area until the oxygen concentration in the area has returned to that of normal air (about 21% by volume) and until the toxic gas concentrations have dropped to traces. At this time, personnel using breathing apparatus will enter the test compartment area to extinguish any remaining smoldering items and cover the fuel pan. The corridor doors at the fore and aft ends will be opened to permit the smoke to be exhausted in the aft direction by using portable blowers.

7.4 Fire Extinguishment

During test preparations, as well as during the actual testing, a sufficient number of portable AFFF extinguishers should be readily available in the test area in case of emergency.

7.5 Heptane Supply

Before checking operation of the fuel supply, all other instrumentation should be installed and fully operational. All combustible material should be removed from the test compartment and the area of the passageway near the test compartment doorway. Heat flux data should be recorded during this test run, which should continue for at least 15 minutes. In the event the fire extinguishes from lack of oxygen, the fuel pan should be drained.

8.0 REPORTING

The CG R&D Center will reduce the data and supply it in a usable form including prints, photos, and magnetic tapes to the Navy, NRL Code 6183 which will document the test procedures and present experimental results. Analysis, discussion, conclusions and recommendations will not be included. The report will include the results from all tests including background tests.

APPENDIX A-1
INSTRUMENTATION

Test Number: ________ Date: ________

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
0	O_2 concentration, L&N 7803-G	Test Compartment[a]	0-.005	73-69702-1-1	0-25%
1	O_2 concentration, L&N 7803-G	Passageway-6' AFT Compt Door[a]	0-.005	74-50059-1-1	0-25%
2	O_2 concentration, L&N 7803-G	After Compartment[a]	0-.005	74-50059-1-2	0-25%
3	CO_2 concentration, MSA LIRA 303	In Conjunction with O_2 Analyzers	0-.1	30606	0-25%
4	CO_2 concentration, MSA LIRA 303		0-.1	31334	0-25%
5	CO_2 concentration, MSA LIRA 303		0-.1	31335	0-25%
6	CO concentration, MSA LIRA 303	In Conjunction with O_2 Analyzers	0-.1	-	0-0.5%
7	CO concentration, MSA LIRA 303		0-.1	-	0-0.5%
8	Co concentration, MSA LIRA 303				
9	NO_x concentration, Beckman 951	Test Compartment[a]	0-1	0100048	0-250 ppm
10	NO_x concentration, Beckman 951	Passageway[a]	0-1	0100049	0-250 ppm
11	SO_2 concentration, Beckman 865	In Conjunction with NO_x Analyzers	0-1	0102810	0-500 ppm
12	SO_2 concentration, Beckman 865		0-1	0108811	0-500 ppm

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION		OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
13	Hydrocarbon-concen. Beckman 400	In Conjunction with NO_x Analyzers		0-1	1002592	0-10000 ppm
14	Hydrocarbon-concen. Beckman 400			0-1	1002593	0-10000 ppm
20	Hydrogen Cyanide	Test Compartment[a]		0-1.0	TC1183123	ppm HCN 0-1
21	Hydrogen Cyanide	Passageway[a]		0-1.0	TC1183124	ppm HCN 0-1
22	Formaldehyde	Test Compartment[a]		0-1.0	TC1183125	ppm H_2CO 0-5
23	Formaldehyde	Passageway[a]		0-1.0	TC1183126	ppm H_2CO 0-5
24	Hydrogen Chloride	Test Compartment[a]		0-1.0	TC1183119	ppm HCl 0-10
25	Hydrogen Chloride	Passageway[a]		0-1.0	TC1183120	ppm HCl 0-10
26	Phosgene	Test Compartment[a]		0-1.0	TC1183117	ppm $COCl_2$ 0-.25
27	Phosgene	Passageway[a]		0-1.0	TC1183118	ppm $COCl_2$ 0-.25
28	Chlorine	Test Compartment[a]		0-1.0	TC1183121	ppm Cl_2 0-2
29	Chlorine	Passageway[a]		0-1.0	TC1183122	ppm Cl_2 0-2
30	Thermocouple, Type K, *Inconel-sheathed*		After outside	0-.0435	-	0-1000°C
31	Thermocouple, Type K, *Inconel-sheathed*	Test Compartment Beside Cable Bundles	After inside	0-.0435	-	0-1000°C
32	Thermocouple, Type K, *Inconel-sheathed*		Forward outside	0-.0435	-	0-1000°C
33	Thermocouple, Type K, *Inconel-sheathed*		Forward inside	0-.0435	-	0-1000°C
34	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
35	Thermocouple, Type K, Inconel-sheathed		Test Compartment String #1	0-.0435	-	0-1000°C
36	Thermocouple, Type K, *Inconel-sheathed*			0-.0435	-	0-1000°C
37	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION		OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
38	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
39	Thermocouple, Type K, Inconel-sheathed		Test Compartment String #2	0-.0435	-	0-1000°C
40	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
41	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
42	Thermocouple, Type K, Inconel-sheathed	Outside	After Compartment Beside Cable Bundle	0-.0435	-	0-1000°C
43	Thermocouple, Type K, Inconel-sheathed	Inside		0-.0435	-	0-1000°C
44	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
45	Thermocouple, Type K, Inconel-sheathed		Test Compartment String #3	0-.0435	-	0-1000°C
46	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
47	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
48	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
49	Thermocouple, Type K, Inconel-sheathed	Test Compartment doorway. Combined with String #6. (See Figure 3).	Test Compartment String #4	0-.0435	-	0-1000°C
50	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
51	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE -ENGINEERING UNITS
52	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
53	Thermocouple, Type K, Inconel-sheathed	After Compartment String #5	0-.0435	-	0-1000°C
54	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
55	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
56	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
57	Thermocouple, Type K, Inconel-sheathed	Test compartment doorway. Combine with String #4. (See Figure 3) Corridor String #6	0-.0435	-	0-1000°C
58	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
59	Thermocouple, Type K,		0-.0435	-	0-1000°C

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE *ENGINEERING UNITS
60	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
61	Thermocouple, Type K, Inconel-sheathed	In Cable Bundle 12" apart	0-.0435	-	0-1000°C
62	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
63	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
64	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
65	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
66	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
67	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
68	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
69	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
70	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
71	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
72	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
73	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
74	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
75	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
76	Thermocouple, Type K, Inconel-sheathed	Fire Pan	0-10	-	0-.1"H_2O
77	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
78	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
79	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
80	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
81	Thermocouple, Type K, Inconel-sheathed	Bulkhead Fire Room	0-10	-	0-.1"H_2O
82	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
83	Thermocouple, Type K, Inconel-sheathed		0-10	-	0-.1"H_2O
84	Calorimeter	From Fire	-	-	-
85	Calorimeter	Doorway	-	-	-
86	Calorimeter	Not assigned	-	-	-
87	Calorimeter	Not assignedot	-	-	-
88	Calorimeter	Not assigned	-	-	-
89	Calorimeter	Not assigned	-	-	-
90	Radiometer	48" above deck Forward Room	-	-	-
91	Radiometer	48" above deck After Room	-	-	-
92	Smoke obscuration, laser source	88" above deck Test Room	0-.1	-	0-100%T
93	Smoke obscuration, laser source	56" above deck Test Room	0-.1	-	0-100%T
94	Smoke obscuration, laser source	24" above deck Test Room	0-.1	-	0-100%T
95	Smoke obscuration, laser source	8" above deck Test Room	0-.1	-	0-100%T

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
96	Smoke obscuration, laser source	56" above deck Passageway	0-.1	-	0-0100%T
97	Smoke obscuration, laser source	24" above deck Passageway	0-.1	-	0-100%T
98	Radiometer	48" above deck Test Room forward outside			
99	Radiometer	48" above deck Test Room after outside			
100	Radiometer	48" above deck Test Room forward near passage			
101	Radiometer	48" above deck Test Room after near passage			
102	Smoke obscuration, laser source	48" above deck After Compartment			
103	Smoke obscuration, laser source	48" above deck Forward Compartment			
104	Smoke obscuration, laser source	48" above deck Test Compartment			
105	Smoke obscuration, laser source	48" above deck Passageway			
		Miscellaneous			
106	Heat detector, thermal, Fenwal	Ceiling, aft end of corridor	0-1.5	-	0 Volts = Normal 1 Volts = Alarm
107	Barometric Pressure	Instrumentation trailer	0-.1	-	27-31.5"Hg
108	Relative Humidity	Instrumentation trailer	0-.1	-	0-100% R.H.
109	Logic Switch 1		0-1.5	-	0V off, 1.5V on
110	Logic Switch 2		0-1.5	-	0V off, 1.5V on
111	Logic Switch 3		0-1.5	-	0V off, 1.5V on
112	Logic Switch 4		0-1.5	-	0V off, 1.5V on
113	Logic Switch 5		0-1.5	-	0V off, 1.5V on
114	Logic Switch 6		0-1.5	-	0V off, 1.5V on
115	Load Cell	Fuel Pan	0.1	-	0-500 lbs
116		Ref. Junction Temperature (Trailer)			-10 + 50°C

[a] Integrated sample taken at three levels, 24", 48" and 72" from the deck

APPENDIX A-2
INSTRUMENTATION

6	Radiometers, Gardon 0-10 BTU/ft^2min Type 64 15R -20 -6 MgO Range 9 - 12 MV, 15 BTU/ft^2sec
2	Calorimeters, Gardon 0-10 BTU/ft^2min Type 64 -2 - 20 - 8 MgO 5 Range 0 - 2 BTU/ft^2 - sec Type 64 -2 - 20 3
54	Thermocouple, Type K, Inconel - sheathed
10	Smoke Obscuration, Spectra Physics lasers RCA Modl C30810
3	Oxygen analyzer, LCN Thermomagnetic (0-25%) model 7803-6
3	Carbon Dioxide analyzer, MSA Model LIRA 303 (0-25%) Full Scale
3	Carbon Monoxide analyzer, MSA Model LIRA 303 (0-5%) Full Scale
2	NO_x analyzer, Beckman, Model 951
2	Sulphur Dioxide analyzer, Beckman NDIR- Model 865
2	Hydrocarbon Analyzer, Beckman Flame-Ionization Model 400
1	Heat Detector, Fenwal
1	Hygro-thermograph
1	Load Cell (Fuel Pan 0-50016)
2	Colorimetric HCN (CEA Model TGM 555)
2	Colorimetric Formaldehyde (CEA Model TGM 555)
2	Colorimetric HCl (CEA Model TGM 555)
2	Colorimetric Phosgene (CEA Model TGM 555)
2	Colorimetric Chlorine (CEA Model TGM 555)
36	1.4 liter Stainless Steel Bottle/Solenoids
1	Particle Analyzer
1	Monochrometer (Jarrel Ash)

APPENDIX B
n-HEPTANE DATA SHEET

HEPTANE

Description: Colorless liquid.
Formula: $CH_3(CH_2)_5CH_3$
Constants:
   Mol. Wt. 100.20
   B. P. 98.52°C
   Freezing P. -90.5°C
   Flash P. 25°F (C.C.)
   Density 0.684 @ 20°/4°C
   Autoign. Temp. 452°F
   Vap. Press. 40 mm @ 22.3°C
   Vap. D. 3.45

Toxic Hazard Rating:
   Acute Local: 0
   Acute Systemic: Inhalation 1
   Chronic Local: U
   Chronic Systemic: U
MAC: ACGIH (accepted); 500 parts per million in air; 2045 milligrams per cubic meter of air.
Fire Hazard: Dangerous, when exposed to heat or flame.
Spontaneous Heating: No
To Fight Fire: Foam, carbon dioxide, dry chemical

Explosion Hazard: Moderate, when exposed to heat or flame.
Explosive Range: 1.2 - 6.7%
Disaster Control: Dangerous, upon exposure to heat or flame; can react vigorously with oxidizing materials.
Ventilation Control (use moderate rate): Section 2
Storage and Handling: Section 7
Shipping Regulations: Section 11.
   I.C.C. Classification: Flammable liquid; red label.
   Coast Guard Classification: Inflammable liquid; red label.

APPENDIX C
SYSTEMS CHECK LIST

1. Gas Analyzer System

   a. Dryer system: moisture out? leakage?
   b. Condensation in tubing?
   c. Calibration: O_2, CO_2, CO, HC, SO_2, NO_x before/after response times:
   d. Colorimetric Analyzer system check: ppm levels, response times.
   e. Monochrometer
   f. Particle Analyzer

2. Hydrocarbon Alarm System:

   a. Calibrator gas?
   b. Audible alarm?

3. Smoke Detection/Measurement

   a. Clock starting/stopping
   b. Laser system: alignment, calibration, overheating, before/after fire
   c. Back-lighted strip particule deposit?
   d. Automated cascade impactor

4. Computer

   a. Background check:
   b. Pre-ignition
   c. Ignition: clock-starting, time date gen,
   d. High HC main valve closure check
   e. Graphics check

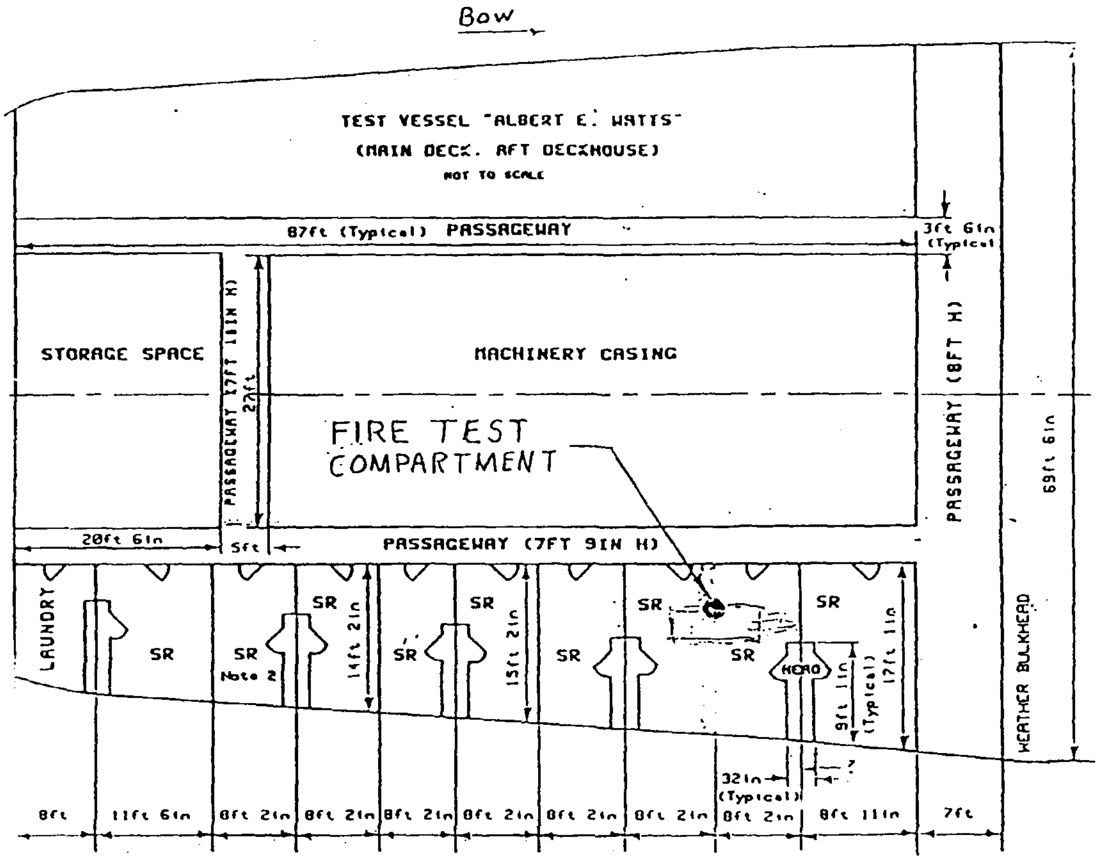
5. Video/Photography:

   a. Cameras, recorders operating
   b. Status board photographed or videotaped before tests
   c. Photos/videotape during test and after
   d. Status board photographed and videotaped after tests

6. Ignition

   a. Check fuel level in pan
   b. Check for HC leak - main deck before and after lighting
   c. Flame quality: blue/yellowing? Flame height steady? Ventilation regulation?

FIGURE 1. Fire Test Compartment Location



Compartment dimensions are internal.

NOTES:

1. Compartment dimensions are internal as shown.
2. Drain lines routed through doorway (overboard discharge).
3. All Heads same size; Head Doors are 27"w by 70"h.
4. Passageway Doors are 27"w by 72"h.
5. All Doors are 16" from top of door to overhead; 7" from bottom of door to Deck.

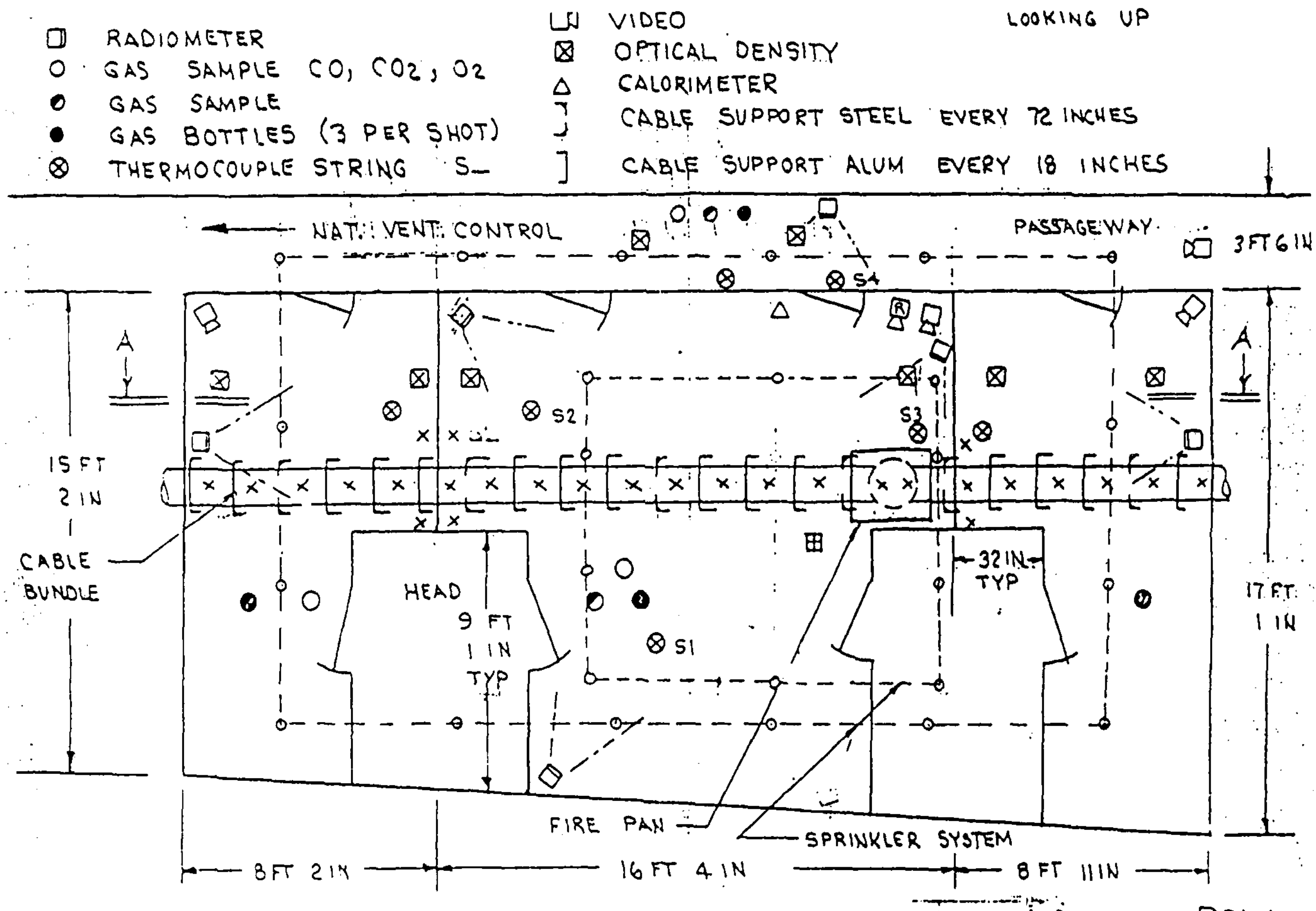


FIGURE 21. TEST CONFIGURATION.
(Forward Four Starboard Staterooms)

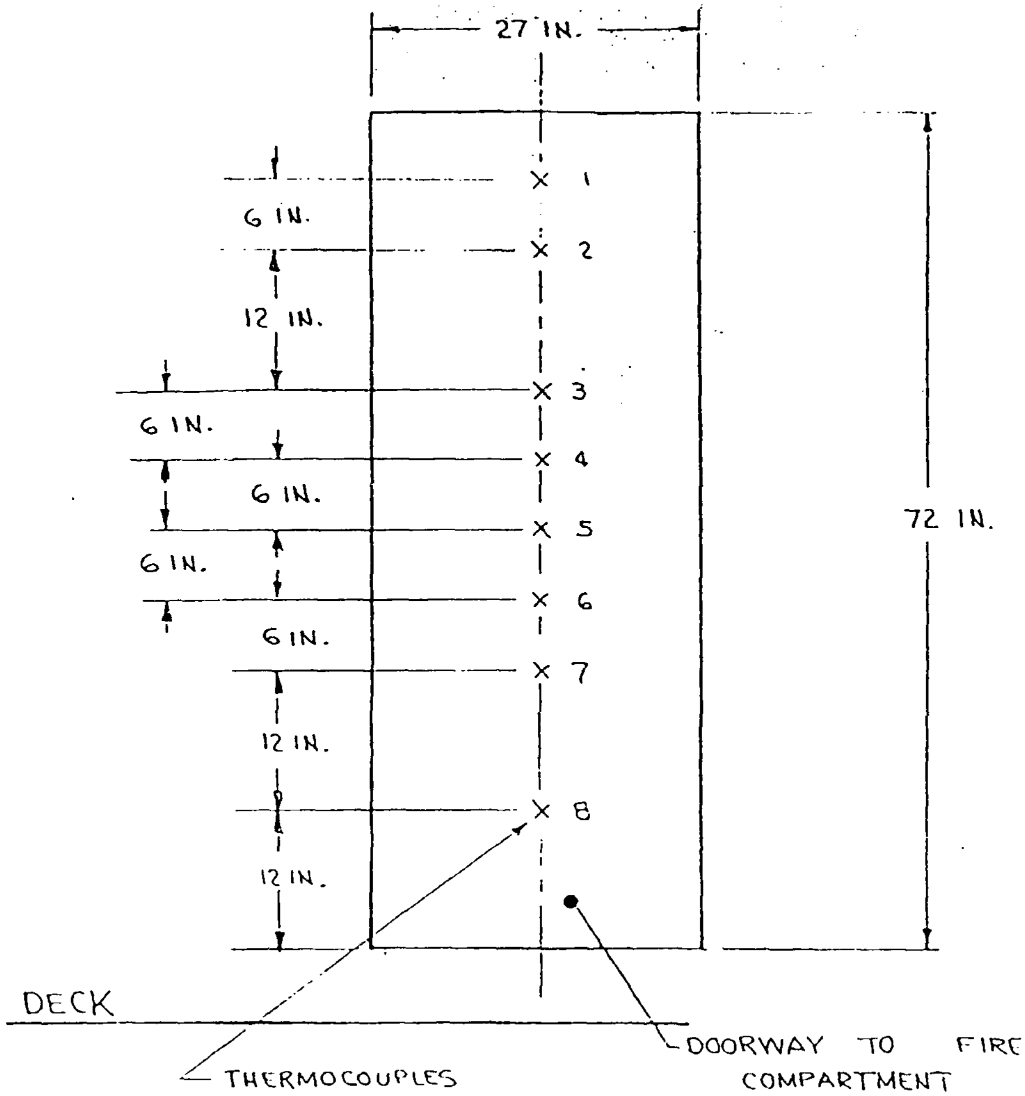


FIGURE 3. RECOMMENDED LOCATIONS OF 8 T/C's ; STRING NO. 4 AND STRING NO. 6

CABLES TO BE TESTED

Cable	Feet Required	E	F	MIL-C XXXXX	MIL-C 17
TSGU-50	1500	✓	✓		
TSGA-50	1500	✓	✓		
MDU-6	1000	✓	✓		
2SWAU-10	1000	✓	✓		
2XSAW-10	1000			✓	
TSGU-23	2000	✓	✓		
TSGA-23	2000	✓	✓		
MSCU-10	1500	✓	✓		
MXCW-10	1500			✓	
RG-11	1000				✓
RG-108	1000				✓
RG-223	1000				✓
RG-216	1000				✓
TTRS-6	1000	✓	✓		
TTRSA-6	1000	✓	✓		
TTXS-6	1000			✓	

17-By Frequency
CG-47

CABLE LEGEND

1	TSGA-50	7	2SWAU-10
2	MDU-6	8	TSGU-23
3	TSGU-50	9	MSCU-10
4	TTRSA-16	10	MXCW-10
5	TTRS-6	11	TTXS-6
6	TSGA-23	12	2XSAW-10

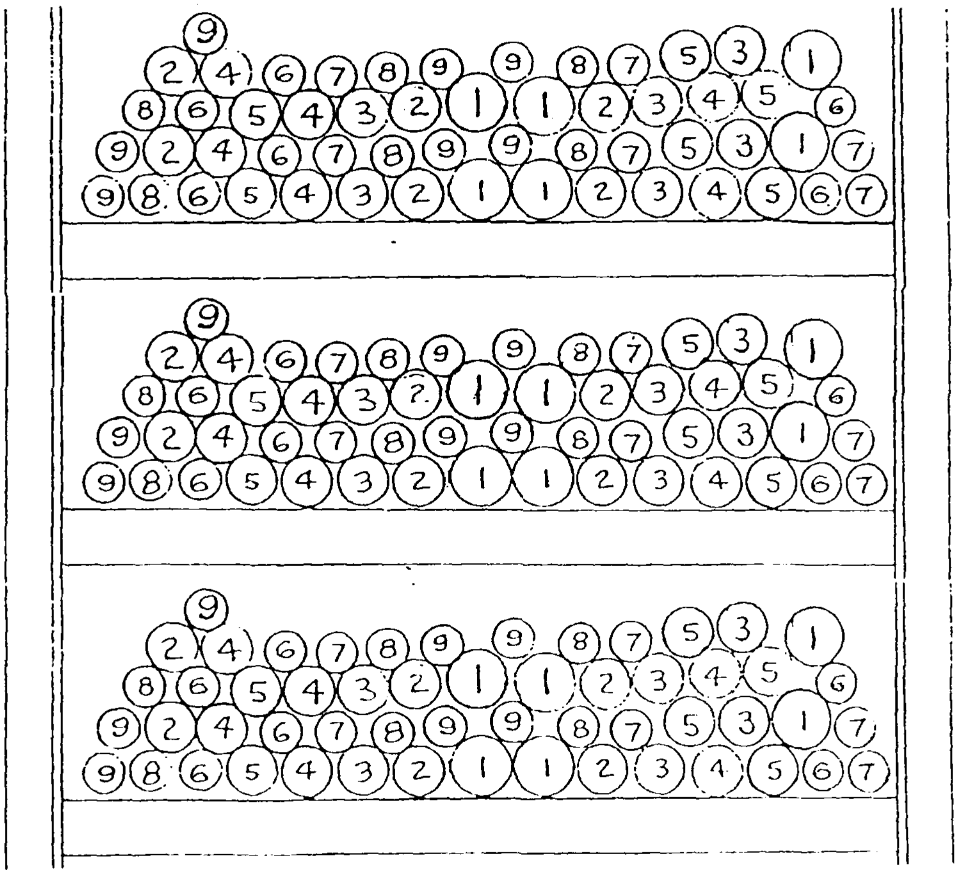


FIGURE 5 Three-tier test configuration,
U.S. Navy Communication & Power Cable Fire Tests

OUTLINE OF NAVY CABLE FIRE FIGHTING TEST SERIES

	Tasks	Number of Tests	Test Number
Task I.	ESTABLISH CONDITIONS Equipment Checkout (gas analyzers, Temp sensors, heat flux meters, gas samplers, smoke gas samplers, smoke sensors), Fire Fighting Procedure	2 tests	NT(W29), NT(W30)
Task II.	NAVY CABLE MANUAL FIRE FIGHTING TESTS	3 tests	NT(W31), NT(W32), NT(W33)
Task III.	Navy Cable Sprinkler Fire Fighting Test	1 tests	NT(W34)

OUTLINE (continued)

TASK I. Establish Operating Conditions

Test W29 - (1.1) Compartments configured (Aluminum bulkhead and Steel bulkheads, overhead and deck) no cables (2'x2' heptane pan, 4 gallons), No Fire Fighting

(1.2) Instrumentation - All

(1.3) Video and photographs

(1.4) Data Reduction - On site

1. Temperatures in compartments - individual plots
2. Temperatures in corridor
3. Radiometers - individual plots
4. Load cell for the pan
5. CO, O_2, CO_2 - individual plots
6. Data tape in NRL format (1600 BPL) within 24 hrs.
7. Complete channel listing

Test W30 - (2.1) Compartments configured (Aluminum bulkhead and Steel bulkheads, overhead and deck) no cables (2'x2' heptane pan, 4 gallons)

(2.2) Instrumentation - All

(2.3) Video and photographs

(2.4) Date Reduction - On site

1.
2.
3. Same as Test W29
4.
5.
6.
7.

(2.5) Fire fighting commence 12 min after fire start

TASK II. Navy Cable Manual Fire Fighting Tests

Test W31 - (3.1) Compartments configured (Aluminum bulkhead and Steel bulkheads, overhead and deck) cables (MIL-E-915E-Amend 2) (2'x2' heptane pan, 4 gallons)

(3.2) Instrumentation - All

(3.3) Video, movies and photographs

(3.4) Data reduction - on site - same as for Test W29 and Test W30

(3.5) Manual Fire fighting Commence 25 min after fire start, fire main pressure of 60+ psig.

<u>Test W32</u> - (4.1) Same as 3.1

(4.2) Instrumentation - All

(4.3) Video, movies and photographs

(4.4) Data Reduction - On site

1. Temperature in compartments - individual plots
2. Temperatures in corridor
3. Optical density in corridor
4. Radiometer - individual plots
5. Fire pan load cell
6. All continuous gas analyses on individual plots
7. Data tape in NRL format (1600 BPL) within 24 hrs.
8. Complete channel listing.

(4.5) Same as W31, except fire main pressure of 25 psig.

<u>Test W33</u> - Same as Test W32 except cables will be MIL-C-915E-Pre Amend 2

TASK III. <u>Fixed Suppression of Navy Cable Fire</u>

<u>Test W34</u> - (5.1) Same as 3.1

(5.2) Same as 3.2

(5.3) Same as 3.3

(5.4) Same as 3.4

(5.5) Commence auto fire fighting after 25 minutes preburn

FIRE FIGHTING TESTS OF NAVY COMMUNICATION AND POWER CABLE

TEST PLAN

30 MAY 1985

TABLE OF CONTENTS

TEST PLAN FOR FIRE FIGHTING TESTS
OF NAVY CABLES

1.0 INTRODUCTION

1.1 Background

a. The U.S. Navy has power cables installed on ships specified under MIL-C-915E-Amend 2 and pre-MIL-C-915E-Amend 2. When involved in a fire these cables contribute significantly to the fuel load, add to fire spread, and produce vast quantities of black smoke, acid gases and toxic products.

b. Two new Military Specifications are being used in new ship construction, MIL-C-24643 and MIL-C-24640. These specifications deal with light-weight power cables which ostensibly will produce less smoke, acid gas and toxic by-products when involved in a fire.

c. These new cables do not address the cable fire problem of existing ships as the cost of replacing the cables is prohibitive. Therefore, the impact of cable fire fighting on maintaining the ships' mission is significant.

1.2 OBJECTIVE

The adequacy of current fire fighting techniques for both surface ships and submarines on burning shipboard cables will be determined. Both manual and fixed suppression techniques will be used. The ability of smoke curtains to contain smoke will also be evaluated.

2.0 APPROACH

2.1 General

The forward four compartments and passageway on the starboard side of the 01 deck, after deck house, of the A.E. WATTS will be used as the test compartments for the full-scale fire tests. See Figure 1. These are the same test compartments currently being used in the Navy cable fire tests.

Sprinkler heads, to be furnished by the Naval Sea Systems Command, will be installed in the overhead and will have remote actuation capability.

The cables will be installed according to Navy requirements with both vertical and horizontal configurations. The cable installation will be the same as in previous Navy Cable Tests. The source of ignition will be a heptane liquid fuel fire.

No forced ventilation will be provided, but the fire compartment will be open to the passageway. These fire fighting cable tests will be conducted with pre-MIL-C-915-E-Amend 2 and MIL-C-915-E-Amend 2 cables. Both manual and fixed fire fighting will be performed on these cables in four tests. Two additional background fires will be conducted without cables, one with and one without fire fighting.

2.2 Fire Scenario

The tests will simulate a fire involving cables, using as a source of ignition a n-heptane fuel fire in a square pan, 2' x 2'. Sufficient fuel will be used for a 15 minute pan fire burn. The cables in the area of the simulated motor generator will be subjected directly to the pan fire.

Since the primary objective is to determine the ease of fire fighting of electrical cables, no other combustibles will be present in the compartment.

The basis for comparison in this series of tests will be the ease of fire suppression and conversely flame spread. Also, smoke curtains will be evaluated in the passageway and in the adjoining compartment to the fire room.

Sequence of Events

a. Doors to passageway closed except the test compartment doors and where smoke curtains are being evaluated.

b. Data acquistion system started.

c. Fire started.

d. Fire fighting effort will commence 25 minutes after fire start except test W-30 where no cables will be installed. Fire fighting will commence 12 minutes after the fire start.

e. Data are recorded until all fire activity has ceased.

3.0 THE TEST AREA

3.1 Test Spaces

The tests will be performed on board the tanker vessel ALBERT E. WATTS in test compartments and passageway on starboard side after deck house on the 01 level. Figure 1 shows the compartment plan. The after bulkhead of the fire test area will

be aluminum. The cables will be installed according to Navy specifications with steel and aluminum open cable hangers.

3.2. Environmental Control

All compartments, except the test compartment and the smoke curtain compartments, should be secured and no forced ventilation will be used. Standard cable penetration will be used. The cable penetrations between compartments will be sealed with duct seal according to Navy procedure. No other special gas tight precautions will be taken.

3.3 Fuel Supply/Ignition System

The fuel to be used is n-heptane, with the quantity being dictated by a burn time of 15 minutes. A spark created from a neon sign tranformer, ignites a propane flame, which in turn ignites the heptane fuel. A way will be provided to fill and drain the fuel pans remotely from the weather deck for safety reasons.

3.4 Extinguishment System

Extinguishment of fires W-30, W-31 and W-33 will be accomplished with a single handline, 1½", 90 psig. The fire fighting effort will commence 25 minutes after ignition of the pan fire. A Navy Vari-nozzle will be used. Fire W-32 will use a 25 psig backing pressure to simulate submarine trim and header pressures. Fire W-34 will employ a fixed suppression system with nozzles to be furnished by Naval Sea Systems Command.

4.0 INSTRUMENTATION

4.1 Background Conditions

Instruments will be used to measure background environmental conditions before and after the fires. These will include:

a. Recording barometer
b. Wind direction and speed (measure also during test).
c. Ambient humidity
d. Outside temperature

4.2 Thermocouples (See Figure 1)

Type K, inconel-sheathed thermocouples will be used to measure air, cable bundle and bulkhead temperatures in the following locations:

a. One vertical string, four thermocouples per string, in the test compartment located at 16", 48", 64" and 80" above the deck. Four thermocouples will be located 12 in. from the cable penetration on the forward and after bulkheads.

b. Thermocouples will be placed in the cable bundle 12 in. apart in the fire room and the compartments fore and aft of the fire room.

c. Thermocouples will also be placed on the opposite bulkheads in the forward and after compartments.

d. Individual thermocouples will also be placed on each side of the cable bundles on each side of the bulkheads (total of eight couples).

e. Two thermocouples will be over the fuel pan to monitor if the fire extinguishes prematurely.

f. All thermocouples rakes from the previous Navy cable test will be removed.

4.3 Calorimeters (See Figure 1)

Calorimeters to measure total heat flux will be placed as follows: three calorimeters to be installed in the fire compartment near the surface of the aluminum (after bulkhead) and two steel (forward and passageway) bulkheads. These will be located mid level in the compartment. Calorimeters will also be placed in the forward, after compartment and passageway.

4.4 Radiometers (See Figure 1)

a. Two radiometers will be installed in the test compartment in the after outside and inside corners at mid level, and on the deck near the center of the fire area looking up.

b. Two radiometers will be installed in the forward and after compartments on bulkhead opposite the test compartment, mid level.

c. One radiometer will be installed in passageway.

4.5 Air Velocity Probes

None will be installed.

4.6 Gas Analyzers (See Figure 1)

a. Gas analyzers will be used to continuously measure oxygen, carbon dioxide, carbon monoxide, total hydrocarbons, and nitrogen oxides from sample line inlets located 24", 48" and 72"

(integrated sample) above the deck near the center line string of thermocouples in test compartment. Separate gas analyzer inlet (integrated inlets) for separate banks of analyzers (CO, CO_2 and O_2) will be located in approximately the same location in the forward compartment. A gas analyzer inlet will also be in the passageway outside the test compartment (complete set of analyzers).

Analyzers

1. 3 Paramagnetic Oxygen Analyzers
2. 3 IR CO_2 Analyzers
3. 3 IR CO Analyzers
4. 2 NO Analyzers

4.7 <u>Grab Samplers</u>

None in this test series.

4.8 <u>In Situ IR Analyzers</u>

None in this test series.

4.9 <u>Load Cell</u>

Load cell for the fuel pan will measure the fuel consumption rate.

4.10 <u>Visual and Audio Recordings</u>

a. Two visual color video cameras protected from the fire will view as much of the test compartment as possible.

b. Two additional color video cameras will view down the passageway on each side of the fire curtain.

c. Two color cameras will view the forward and after compartment.

d. One IR camera will be located in the test compartment.

e. Still photographs (35 mm) will be taken before and after each test. A remote motor driven 35 mm camera will be used to photograph the fire fighting.

f. One 16 mm movie camera will photograph the fire fighting activity in the test compartment.

g. Audio recording in proximity of the test (decibel level).

h. Audio recording of interactive personnel in a test and comments (perceptions, intelligibility, communication).

4.11 Smoke Characterization

a. The smoke obscuration measurements will be made in the forward and after compartment and in the passageway. The locations will be midlevel near the gas inlet locations. At these points, the transmittance of light issuing from a low-powered laser emitter (0.5 mw, 0.632 μ wavelength) will be measured by a photo-diode detector 12" from the laser. To avoid inaccurate readings from the temperature-sensitive detector units, they will be located on the deck below the test level. Laser light at the 12" distance will be transmitted through fiber optic cables.

4.12 Continuity Test

Voltages ranging from 3.0 down to 0.2 of volts are converted to 15 conductors in the cables. This then allows the determination of the time of failure of a cable and will to an extent measure the effect of water on the cables.

5.0 PRE-TEST FACILITY AND EQUIPMENT CALIBRATION

5.1 Install sprinkler heads

5.2 Familiarize operating personnel with calibration and operation of all analytical equipment.

5.3 Verify operation of all analytical equipment

5.4 Determine delay time to analyzers.

5.5 Using the base line test, establish the time-temperature curves for the fuel pans/compartment.

5.6 Fire curtains will be installed on the hatches of the forward and after compartment adjacent to fire room. Fire curtain will also be installed in passageway.

6.0 TEST PROCEDURE

6.1 Test Preparation

All instruments will be calibrated and checked. All personnel taking part in the test will be briefed on their respective roles. All the doors to the test area and inside the test area will be closed and sealed if necessary. Video tape recordings, 35 mm photographs and movies will be made as necessary to document the appearance of the test compartment, specimens, and instrumentation prior to each test.

6.2 Baseline Test

Two baseline tests will be conducted with full instrumentation. No cables will be installed and cable feed-throughs will be sealed. One test will be without fire fighting and the other will be with fire fighting.

6.3 Commencement of the Test

Prior to actual ignition of the fuel, all instrumentation will be turned on and scanned for at least five minutes. The scan-time of five minutes will be used to establish baseline measurements. The pan will be fueled three minutes into the scan time, the level determined by video and premeasurement. The pan will be lighted. The timing clocks will be started at the instant the fuel is lighted. That instant will be time zero. Also recorded will be the time when the cables become involved in the fire.

The fire fighting effort will commence 25 minutes into the test for the cable tests and 15 minutes into the fuel pan test only. The fire fighting team will be led by Navy fire fighters.

6.4 Data Acquisition

Data collection will be accomplished in the instrumentation trailer located on board an LCM moored beside the test vessel. Wire leads and gas sampling tubes from the instruments will be led from the test area to the deck below and then to the trailer.

6.5 Termination of the Test

The test will be terminated when all fire activity ends or at any other time that may be decided by the test director. The test will also be terminated for any other reason if the test director or the F&STD supervisor judges that safety of the personnel is threatened.

At termination, any remaining fuel will be drained before personnel go into the test area. When the corridor temperature has dropped to about 120°F, the oxygen level has returned to normal, and the toxic gas concentrations in the corridor have dropped to traces, personnel using breathing apparatus and carrying carbon dioxide extinguishers and a backup hand line will enter the corridor and test compartment. Any smoldering embers will be extinguished using a minimum amount of CO_2 from the portable extinguishers. Remains of the test specimens should be disturbed as little as possible prior to inspection and photographic documentation.

Before moving the remains of the test specimens, observations on the conditions inside the test compartment will be recorded, and videotape recordings and 35mm color photographs will be made to provide a record of the appearance of the specimens after the tests. The remains of the specimens will then be removed and the test compartment will be cleaned and prepared for the next test.

6.6 Cables Fire Fighting Tests

Four fire fighting tests involving cables are planned: three tests will be conducted with manual fire fighting, one using old cable MIL-C-915-E Pre Amend 2 and two using MIL-C-915-E Amend 2. Handlines of 1½" using 90 and 25 psig water will be used. Navy fire fighters will head the fire fighting efforts. One fixed suppression test will be conducted with nozzles the Navy furnishes.

7.0 SAFETY

7.1 Safety Responsibilities

Safety of the personnel is of paramount importance throughout preparation and testing. The F&STD Supervisor is the safety officer for all operations relating to the testing. The Test Director is responsible for the technical aspects of the tests. A test will be postponed, or, if in progress, terminated, if at any time the F&STD Supervisor or the Test Director decides that the safety of any person is threatened.

7.2 Hazards From Explosive Mixtures

An imporatant safety hazard is that the liquid n-heptane might remain unburned, evaporate and form an explosive mixture with air inside the ship. To avoid such a risk, a hydrocarbon detector and an audible alarm unit will be installed in the main deck area. The alarm is loud enough to warn personnel in the test area of a possible buildup of an explosive gas concentration, so that the fuel can be drained immediately and the test terminated.

The hydrocarbon gas analyzer in the instrumentation trailer will continuously monitor the concentration of hydrocarbon gas (HC) at the location of the gas sampling tube pickups in the test area. The computer will be set so that if HC concentration exceeds 2100 ppm (about 20 percent of the lower flammability limit (LFL)), an audible alarm will be sounded and the heptane drained, terminating the test.

During the test, the test compartment will be observed via the video monitor and IR camera.

7.3 Hazards From Toxic Gases

The analyzers shall be kept in operation after the termination of the test. No one shall enter the test area without breathing apparatus until the oxygen concentration in the test area has returned to that of normal air (about 21% by volume) and until the toxic gas concentrations have dropped to traces. At this time, personnel using breathing apparatus will enter the test compartment area to extinguish any remaining smoldering items and cover the fuel pan. The corridor doors at the fore and aft ends will be opened to permit the smoke to be exhausted in the aft direction by using portable blowers.

7.4 Fire Extinguishment

During test preparations, as well as during the actual testing, a sufficient number of portable AFFF extinguishers should be readily available in the test area in case of emergency.

7.5 Heptane Supply

Before checking the operation of the fuel supply, all other instrumentation should be installed and fully operational. All extraneous combustible material should be removed from the test compartment and the area of the passageway near the test compartment doorway. Heat flux data should be recorded during this test run, which should continue for at least 15 minutes. In the event the fire extinguishes from lack of oxygen, the fuel pan should be drained.

8.0 REPORTING

The CG R&D Center will reduce the data and supply it in a usable form including prints, photos, video tapes, and magnetic tapes to the Navy, NRL Code 6183 which will document the test procedures and present experimental results. Analysis, discussion, conclusions and recommendations will not be included. The report will include the results from all tests including background tests.

APPENDIX A-1
INSTRUMENTATION

Test Number:______________ Date:______________

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE ENGINEERING UNITS
0	O_2 concentration, L&N 7803-G	Test Compartment[a]	0-.005	73-69702-1-1	0-25%
1	O_2 concentration, L&N 7803-G	Passageway-6' AFT Compt Door[a]	0-.005	74-50059-1-1	0-25%
2	O_2 concentration, L&N 7803-G	After Compartment[a]	0-.005	74-50059-1-2	0-25%
3	CO_2 concentration, MSA LIRA 303	In Conjunction with O_2 Analyzers	0-.1	30606	0-25%
4	CO_2 concentration, MSA LIRA 303		0-.1	31334	0-25%
5	CO_2 concentration, MSA LIRA 303		0-.1	31335	0-25%
6	CO concentration, MSA LIRA 303	In Conjunction with O_2 Analyzers	0-.1	-	0-0.5%
7	CO concentration, MSA LIRA 303		0-.1	-	0-0.5%
8	CO concentration, MSA LIRA 303				
9	NO_x concentration, Beckman 951	Test Compartment[a]	0-1	0100048	0-250 ppm
10	NO_x concentration, Beckman 951	Passageway[a]	0-1	0100049	0-250 ppm
11	Flow meters	Measure flow in fire hose	?	On order	? gpm
12	Flow meters	Measure flow in fixed system	?	On order	? gpm

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION		OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE -ENGINEERING UNITS
13	Hydrocarbon-concen. Beckman 400	In Conjunction with NO_x Analyzers		0-1	1002592	0-10000 ppm
14	Hydrocarbon-concen. Beckman 400			0-1	1002593	0-10000 ppm
15	Pressure	Fire hose		?	To be assigned	0-100 psia
16	Pressure	Fixed system		?	To be assigned	0-100 psia
17	Pressure					
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30	Thermocouple, Type K, Inconel-sheathed		After outside	0-.0435	-	0-1000°C
31	Thermocouple, Type K, Inconel-sheathed	Test Compartment Beside Cable Bundles	After inside	0-.0435	-	0-1000°C
32	Thermocouple, Type K, Inconel-sheathed		Forward outside	0-.0435	-	0-1000°C
33	Thermocouple, Type K, Inconel-sheathed		Forward inside	0-.0435	-	0-1000°C
34	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
35	Thermocouple, Type K, Inconel-sheathed		Test Compartment String #1	0-.0435	-	0-1000°C
36	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C
37	Thermocouple, Type K, Inconel-sheathed			0-.0435	-	0-1000°C

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
38	Calorimeter Medtherm Type 64-15-20-6M_gO	Forward Compartment, 36" from aft blkhd, 48" above deck		To be assigned	0-20 Btu/ (ft^2 x sec)
39	Radiometer Medtherm Type 64P-10R-24T-6M_gO	Forward Compartment, 36" from aft blkhd, 48" above dek		To be assigned	0-10 Btu/ (ft^2 x sec)
40	Calorimeter Medtherm Type 64-5-20	Passageway, 15' fwd of fire test doorway, 48" above deck		To be assigned	0-5 Btu/ (ft^2 x sec)
41	Radiometer Medtherm Type 64P-5R-24T	Passageway, 14' fwd of fire test doorway, 48' above deck		To be assigned	5 Btu/ (ft^2 x sec)
42	Thermocouple, Type K, Inconel-sheathed	Outside After Compartment Beside Cable	0-.0435		0-1000°C
43	Thermocouple, Type K, Inconel-sheathed	Inside Bundle	0-.0435		0-1000°C
44	Calorimeter Medtherm Type 64-15-20-6M_gO	Test Compartment. Passageway Bulkhead. 48" above deck		To be assigned	0-15 Btu/ (ft^2 x sec)
45	Radiometer Medtherm Type 64P-20R-247-6M_gO	Test Compartment, near center, looking up from deck 135 window. 150° view.		To be assigned	0-20 Btu/ (ft^2 x sec)**
46	Calorimeter Medtherm Type 64-15-20-6M_gO	Test Compartment, forward bulkhead, 48" above deck		To be assigned	0-15 Btu/ (ft^2 x sec)
47	Radiometer Medtherm Type 64P-20R-24T	Test Compartment, forward bulkhead, 48" above deck. 150° view		To be assigned	0-20 Btu/ (ft^2 x sec)
48	Calorimeter Medtherm Type	Test Compartment, after bulkhead, 48" above deck		To be assigned	0-15 Btu/ (ft^2 x sec)
49	Radiometer Medtherm Type 64P-20R-24T-6M_gO	Test Compartment, after looking up from deck 135 window.		To be assigned	0-20 Btu/ (ft^2 x sec)

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
50	Calorimeter Medtherm Type 64-15-20-$6M_gO$	After Compartment, 36" from fwd bulkhead, 48" above deck		To be assigned	0-20 Btu/ (ft^2 x sec)
51	Radiometer Medtherm Type 64P-10R-24T-$6M_gO$	After Compartment, 36" from fwd bulkhead, 48" above deck		To be assigned	0-10 Btu/ (ft^2 x sec)
52	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
53	Thermocouple, Type K, Inconel-sheathed	After Compartment String #3	0-.0435	-	0-1000°C
54	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
55	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
56	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
57	Thermocouple, Type K, Inconel-sheathed	Corridor String #4	0-.0435	-	0-1000°C
58	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
59	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
60	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
61	Thermocouple, Type K, Inconel-sheathed	In Cable Bundle 12" apart	0-.0435	-	0-1000°C
62	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
63	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
64	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
65	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
66	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
67	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
68	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
69	Thermocouple, Type K, Inconel-sheathed		0-.0435	-	0-1000°C
70	Thermocouple, Type K, Inconel-sheathed		0-0.0435	-	0-1000°C
71	Thermocouple, Type K, Inconel-sheathed		0-0.0435	-	0-1000°C
72	Thermocouple, Type K, Inconel-sheathed		0-0.0435	-	0-1000°C
73	Thermocouple, Type K, Inconel-sheathed		0-0.0435	-	0-1000°C
74	Thermocouple, Type K, Inconel-sheathed		0-0.0435	-	0-1000°C
75	Thermocouple, Type K, Inconel-sheathed		0-0.0435	-	0-1000°C

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
76	Thermocouple, Type K, Inconel-sheathed	Fire Pan	0-0.0435	-	0-1000°C
77	Thermocouple, Type K, Inconel-sheathed		0-0.0435	-	0-1000°C
78	Thermocouple, Type K, Inconel-sheathed		0-0.435	-	0-1000°C
79	Thermocouple, Type K, Inconel-sheathed		0-0.435	-	0-1000°C
80	Thermocouple, Type K, Inconel-sheathed		0-0.435	-	0-1000°C
81	Thermocouple, Type K, Inconel-sheathed	Fire Room	0-0.435	-	0-1000°C
82	Thermocouple, Type K, Inconel-sheathed	String #2	0-0.435	-	0-1000°C
83	Thermocouple, Type K, Inconel-sheathed		0-0.435	-	0-1000°C
84	Cable 1	Continuity	0.2	-	0-3V
85	Cable 2	"	0.4	-	"
86	Cable 3		0.6	-	"
87	Cable 4	"	0.8	-	"
88	Cable 5	"	1.0	-	"
89	Cable 6	"	1.2	-	"
90	Cable 7	"	1.4	-	"
91	Cable 8	"	1.6	-	"
92	Cable 9	"	1.8	-	"
93	Cable 10		2.0	-	"
94	Cable 11	"	2.2	-	"

CHANNEL NUMBER	INSTRUMENT DESCRIPTION	LOCATION	OUTPUT RANGE VOLTS	SERIAL NUMBER	OUTPUT RANGE =ENGINEERING UNITS
95	Spare				
96	Smoke obscuration, laser source	24" above deck Passageway	0-.1	-	0-100%T
97	Cable 12	Continuity	0-2.4	-	0-3V
98	Cable 13	"	0-2.6	-	"
99	Cable 14	"	0-2.8	-	"
100	Cable 15	"	0-3.0	-	"
101	Spare				
102	Smoke obscuration, laser source	48" above deck After Compartment			
103	Smoke obscuration, laser source	48" above deck Forward Compartment			
104	Spare				
105	Spare				
		Miscellaneous			
106	Heat detector, thermal, Fenwal	Ceiling, aft end of corridor	0-1.5	-	0 Volts = Normal 1 Volts = Alarm
107	Barometric Pressure	Instrumentation trailer	0-.1	-	27-31.5"Hg
108	Relative Humidity	Instrumentation trailer	0-.1	-	0-100% R.H.
109	Logic Switch 1		0-1.5	-	0V off, 1.5V on
110	Logic Switch 2		0-1.5	-	0V off, 1.5V on
111	Logic Switch 3		0-1.5	-	0V off, 1.5V on
112	Logic Switch 4		0-1.5	-	0V off, 1.5V on
113	Logic Switch 5		0-1.5	-	0V off, 1.5V on
114	Logic Switch 6		0-1.5	-	0V off, 1.5V on
115	Load Cell	Fuel Pan	0.1	-	0-500 lbs
116		Ref. Junction Temperature (Trailer)			-10 + 50°C

[a] Integrated sample taken at three levels, 24", 48" and 72" from the deck

APPENDIX A-2
INSTRUMENTATION

6	Radiometers, Gardon 0-10 BTU/ft^2min Type 64 15R -20 -6 MgO Range 9 - 12 MV, 15 BTU/ft^2sec
2	Calorimeters, Gardon 0-10 BTU/ft^2min Type 64 -2 - 20 - 8 MgO 5 Range 0 - 2 BTU/ft^2 - sec Type 64 -2 - 20 3
54	Thermocouple, Type K, Inconel - sheathed
10	Smoke Obscuration, Spectra Physics lasers RCA Modl C30810
3	Oxygen analyzer, LCN Thermomagnetic (0-25%) model 7803-6
3	Carbon Dioxide analyzer, MSA Model LIRA 303 (0-25%) Full Scale
3	Carbon Monoxide analyzer, MSA Model LIRA 303 (0-5%) Full Scale
2	NO_x analyzer, Beckman, Model 951
2	Hydrocarbon Analyzer, Beckman Flame-Ionization Model 400
1	Heat Detector, Fenwal
1	Hygro-thermograph
1	Load Cell (Fuel Pan 0-50016)
2	Flow Indicators (Liquid)
2	Pressure in extinguishing System

APPENDIX B
n-HEPTANE DATA SHEET

HEPTANE

Description: Colorless liquid.
Formula: $CH_3(CH_2)_5CH_3$
Constants:
Mol. Wt. 100.20
B. P. 98.52°C
Freezing P. -90.5°C
Flash P. 25°F (C.C.)
Density 0.684 @ 20°/4°C
Autoign. Temp. 452°F
Vap. Press. 40 mm @ 22.3°C
Vap. D. 3.45

Toxic Hazard Rating:
Acute Local: 0
Acute Systemic: Inhalation 1
Chronic Local: U
Chronic Systemic: U
MAC: ACGIH (accepted); 500 parts per million in air; 2045 milligrams per cubic meter of air.
Fire Hazard: Dangerous, when exposed to heat or flame.
Spontaneous Heating: No
To Fight Fire: Foam, carbon dioxide, dry chemical

Explosion Hazard: Moderate, when exposed to heat or flame.
Explosive Range: 1.2 - 6.7%
Disaster Control: Dangerous, upon exposure to heat or flame; can react vigorously with oxidizing materials.
Ventilation Control (use moderate rate): Section 2
Storage and Handling: Section 7
Shipping Regulations: Section 11.
I.C.C. Classification: Flammable liquid; red label.
Coast Guard Classification: Inflammable liquid; red label.

APPENDIX C
SYSTEMS CHECK LIST

1. Gas Analyzer System

   a. Dryer system: moisture out? leakage?
   b. Condensation in tubing?
   c. Calibration: O_2, CO_2, CO, HC, NO_x before/after response times:

2. Hydrocarbon Alarm System:

   a. Calibrator gas?
   b. Audible alarm?

3. Smoke Detection/Measurement

   a. Clock starting/stopping
   b. Laser system: alignment, calibration, overheating, before/after fire

4. Computer

   a. Background check:
   b. Pre-ignition
   c. Ignition: clock-starting, time date gen,
   d. High HC main valve closure check
   e. Graphics check

5. Video/Photography:

   a. Cameras, recorders operating
   b. Status board photographed or videotaped before tests
   c. Photos/videotape/movies during test and after
   d. Status board photographed and videotaped after tests
   e. Movie camera 16 mm remote actuation

6. Ignition

   a. Check fuel level in pan
   b. Check for HC leak - main deck before and after lighting
   c. Flame quality: blue/yellowing? Flame height steady? Ventilation regulation?

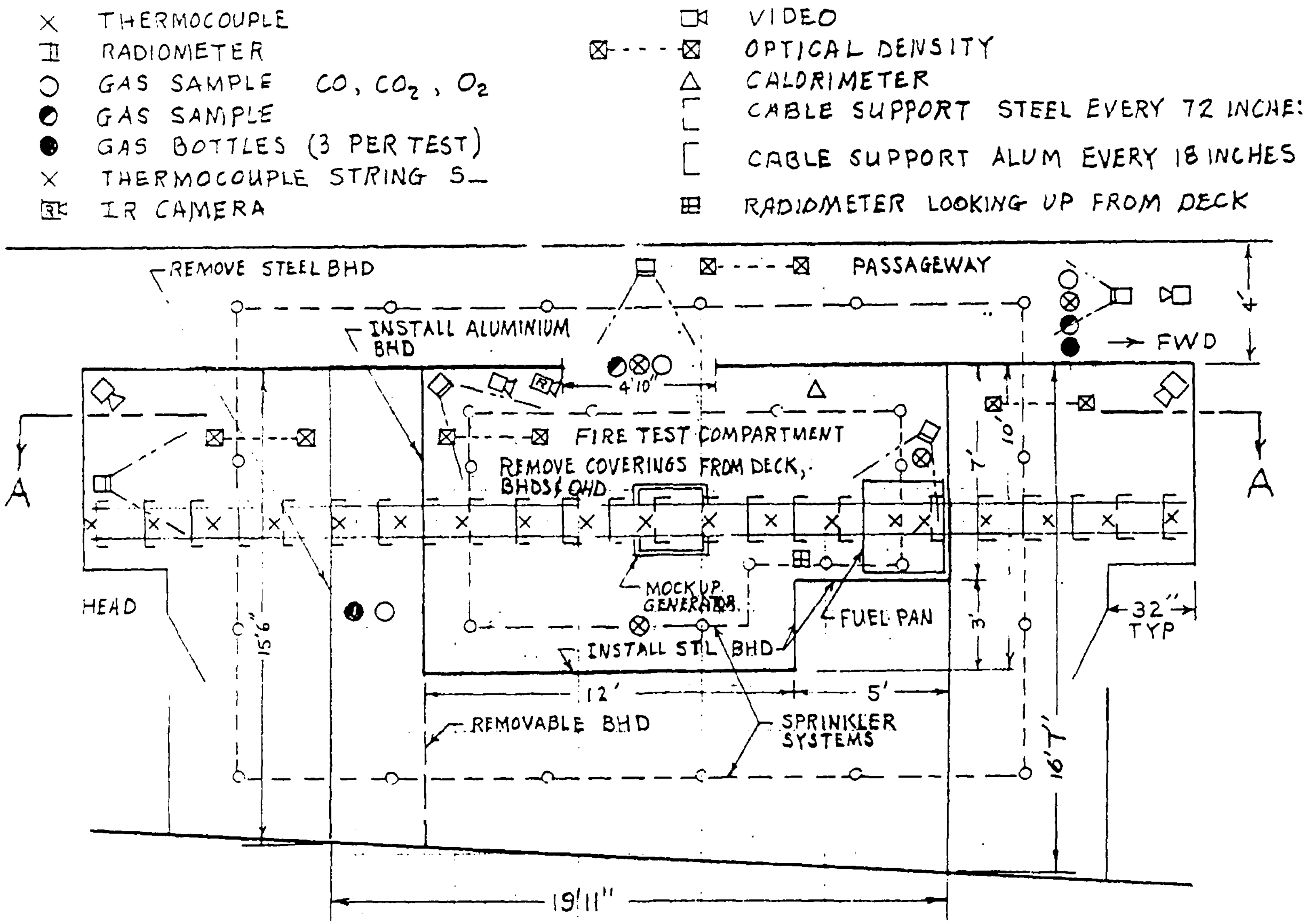
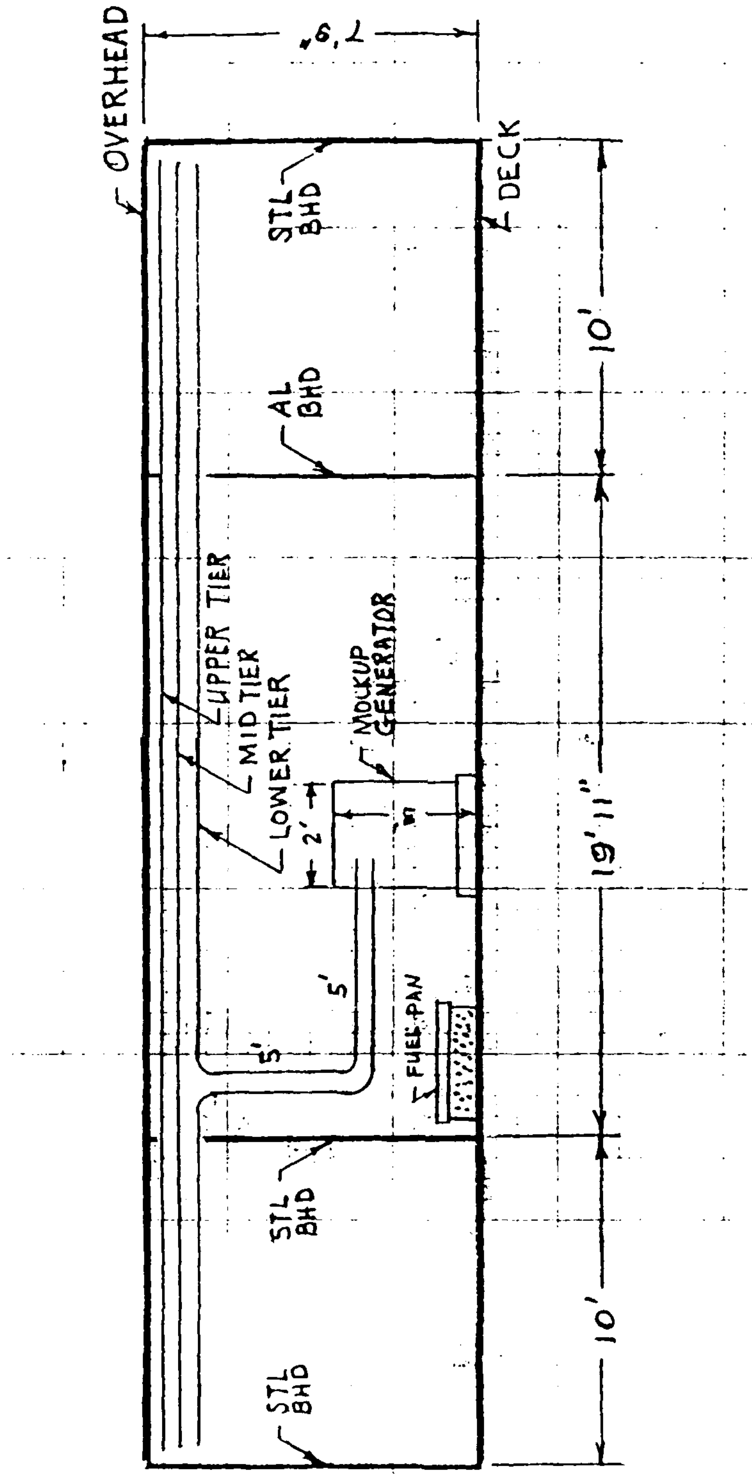


FIGURE 1 - TEST CONFIGURATION



OVERHEAD
DECK
7'9"
STL BHD
AL BHD
STL BHD
STL BHD
UPPER TIER
MID TIER
LOWER TIER
MOCKUP GENERATOR
2'
3'
5'
5'
FUEL PAN
10'
19'11"
10'

VIEW A-A

TABLE I – Power, Control, and Communication Cables in Mobile Fire Tests

CABLE NUMBER	TYPE	MIL SPEC.	SPEC SHEET	DIA (in)	Wt/Ft (lbs)	LENGTH (Ft)
11	TSGA-50	MIL-C-915 Amend 1	30 B	1.02	.882	1680 2200
~~12~~	~~MDU-6~~	~~" "~~	~~12 E~~	~~1.00~~	~~1.08~~	~~980~~ 560
13	TSGU-50	" "	30 B	.97	.823	1680 1680
14	TTRSA-6	MIL-C-915	25 E	.94	.460	1680 2200
15	TTRS-6	"	25 E	.88	.380	1680 1680
16	TSGA-23	MIL-C-915 Amend 1	30 B	.87	.495	2660 2240
17	2SWAU-10	" "	46 A	.83	.36	1680 1680
18	TSGU-23	" "	30 B	.87	.448	1680 1680
19	MSCU-10	" "	32 C	.62	.226	2240 2240
21	TSGA-50	MIL-C-915 Amend 2	30C	1.02	.882	840 420
22	MDU-6	" "	12 F	1.00	1.08	140 560
23	TSGU-50	" "	30C	.97	.823	420 420
24	TTRSA-6	MIL-C-915	25E	.94	.460	840 420
25	TTRS-6	"	25E	.88	.380	420 420
26	TSGA-23	MIL-C-915 Amend 2	30C	.87	.495	560 980
27	2SWAU-10	" "	46E	.83	.36	420 420
28	TSGU-23	" "	30C	.87	.448	420 420
29	MSCU-10	" "	32E	.62	.226	560 560

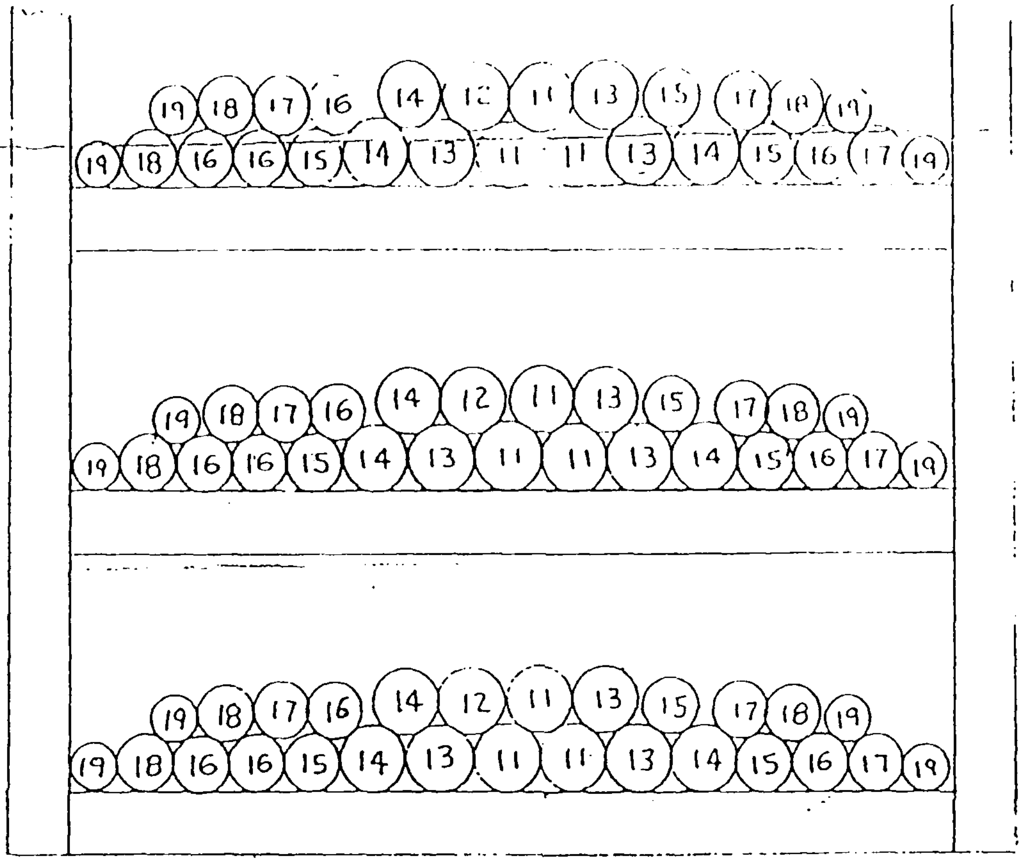


Fig. 1 — Cable Run cross-section for Navy Test W-* looking aft.
See Table 1 for Cable number listing.

TABLE 2 — Navy Test W-*: Total lengths and lengths per tier.

CABLE NUMBER	NUMBER OF CABLES/TIER	UPPER TIER (Ft)	MID TIER (Ft)	LOWER TIER (Ft)	TOTAL (Ft)
11	3	40	40	60	420
12	1	"	"	"	140
13	3	"	"	"	420
14	3	"	"	"	420
15	3	"	"	"	420
16	4	"	"	"	560
17	3	"	"	"	420
18	3	"	"	"	420
19	4	"	"	"	560

* W-33

NAVY TEST W- * 81 MIL-C-915 AMEND 2 CABLES

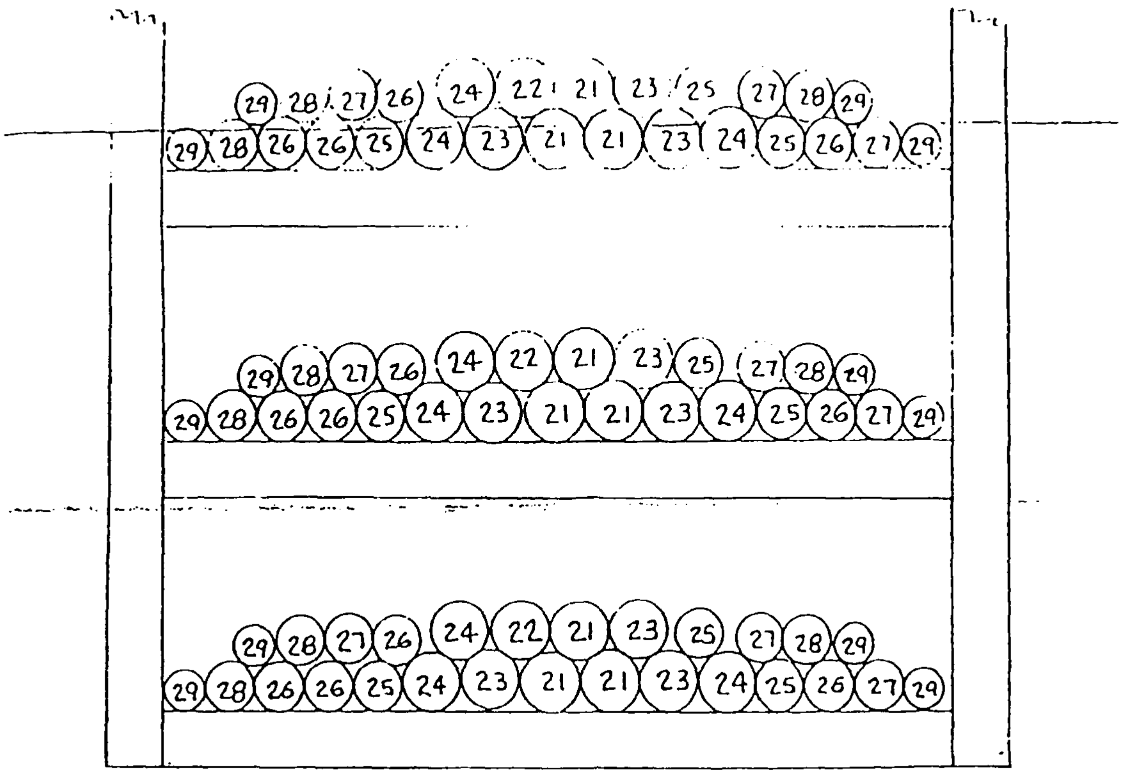


Fig. 4 — Cable Run cross-section for Navy Test W-*. looking aft. See Table 1 for listing.

TABLE 5 — Navy Test W-*: Total lengths and lengths per tier.

CABLE NUMBER	NUMBER OF CABLES/TIER	UPPER TIER (Ft)	MID TIER (Ft)	LOWER TIER (Ft)	TOTAL (Ft)
21	3	40	40	60	420
22	1	"	"	"	140
23	3	"	"	"	420
24	3	"	"	"	420
25	3	"	"	"	420
26	4	"	"	"	560
27	3	"	"	"	420
28	3	"	"	"	420
29	4	"	"	"	560

W-31, 32, 34

END
DATE
FILMED
DTIC
10-88